Assessing the Potential Energy Impacts of Clean Energy Initiatives

Amidst rising concerns about energy prices, the availability of reliable energy resources, air quality, and climate change, many states across the country are using clean energy policies to help meet their expanding electricity demand in a clean, low-cost, reliable manner.

- Nearly 40 states are using planning and incentive structures to promote clean energy within their own operations;

- More than 30 states have adopted a number of regulatory and market-based energy efficiency actions that increase investment in cost-effective energy efficiency by consumers, businesses, utilities, and public agencies; and

- More than 40 states have taken energy supply actions to support and encourage continued growth of clean energy supply.[1]

These actions result in measurable reductions in demand for conventional fossil-fuel-powered electricity as well as reductions in natural gas used for heating, and/or an increase in the amount of electricity generated with clean, renewable energy sources.

This chapter provides state policymakers with methods and examples they can use to estimate the potential direct energy impacts of electricity-related clean energy options for policy and program planning purposes. By understanding the potential energy savings of these programs and policies, state officials can:

- Demonstrate the energy-related impacts of existing and potential clean energy programs;

DOCUMENT MAP

CHAPTER ONE
Introduction

CHAPTER TWO
Potential Energy Impacts of Clean Energy

CHAPTER THREE
Electric System Benefits of Clean Energy

CHAPTER FOUR
Air Quality Benefits of Clean Energy

CHAPTER FIVE
Economic Benefits of Clean Energy

APPENDIX A
Catalogue of Clean Energy Case Studies

APPENDIX B
Tools and Models Referenced in Each Chapter

CHAPTER TWO CONTENTS

---

1 *For more information about which states have implemented these policies, see:* http://www.epa.gov/statelocalclimate/state/tracking/index.html

- Evaluate the implications of new goals, targets, or legislative actions;

- Evaluate the feasibility of or progress toward clean energy-related goals or standards;

- Evaluate the actual and potential effectiveness of technology- or sector-specific clean energy programs in achieving energy savings;

- Compare across clean energy options; and

- Evaluate the actual and potential co-benefits of clean energy policies, including benefits to the energy system, economy, environment, and public health.

As illustrated in the text box *States are Quantifying Potential Direct Energy Impacts of Clean Energy Initiatives*, estimates of potential energy savings serve as a foundation for subsequent analysis of multiple benefits and help demonstrate the value of a program. States can conduct similar analyses of their clean energy programs using methods and tools described in the rest of this chapter.

- Section 2.1 provides a brief explanation of how clean energy initiatives affect energy use and electricity generation requirements.

- Section 2.2 describes methods for estimating potential energy savings or renewable energy generation. This section and the remaining chapters of the *Resource* focus on prospective, rather than retrospective, analyses. See the text box *Retrospective versus Prospective Calculation of Energy Savings* for more information.

- Section 2.3 presents case studies that illustrate how states have used some of these approaches to develop a baseline, a business as usual (BAU) forecast, and energy savings or renewable energy forecasts while planning their clean energy policies.

2.1 HOW DO CLEAN ENERGY POLICIES AFFECT ENERGY?

The two primary objectives of clean energy initiatives are typically to:

1. Implement low-cost energy efficiency measures that reduce the demand for energy, and/or

2. Deploy renewable energy systems (both thermal and electric) or highly efficient cogeneration systems to meet energy demand with the cleanest resources available.

Energy efficiency initiatives include energy efficiency savings goals; energy efficiency portfolio standards; public benefit funds for energy efficiency; building codes; appliance standards; revolving loan programs for energy efficiency; energy performance contracting; and

FIGURE 2.2.1 STEPS TO ESTIMATING ENERGY IMPACTS OF CLEAN ENERGY

STEP 1
Develop a BAU Energy Forecast

STEP 2
Quantify Implications of Targets and Goals

STEP 3
Estimate Potential Direct Energy Impacts

STEP 4
Create an Alternative Policy Forecast
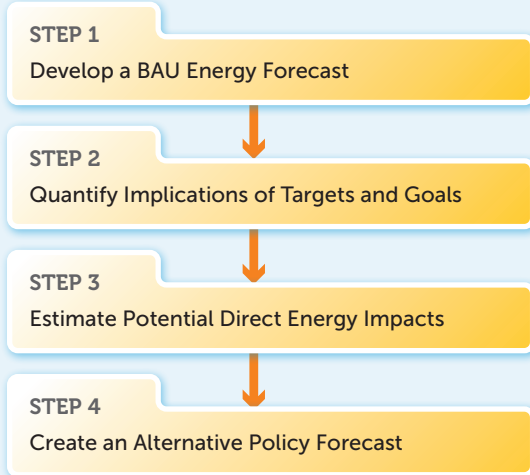
incentives, grants and rebates for efficiency.[2] Through regulatory, market-based, and voluntary approaches, these programs are designed to advance the deployment of energy efficient technologies. The outcome of efficiency efforts is measured in terms of reduced end-use consumption or energy savings (in kWhs or Btus) and peak demand (MW, or maximum Btu/hour), which reduce the amount of energy demanded from generators or delivered from natural gas producers.[3]

Renewable energy initiatives include renewable electricity generation and energy goals; renewable energy portfolio standards; public benefit funds for renewable energy; and revolving loan programs, incentives, and grants and rebates for renewable energy investments. Through regulatory, market-based, and voluntary approaches, these programs are designed to advance the deployment of renewable energy fuels and technologies. Power produced by renewable energy generators displaces supply from existing or planned fossil-fueled electricity generation, sometimes described as "avoided energy."[4]

---

[2] These and other clean energy activities are described in the EPA Clean Energy-Environment Guide to Action: Policies, Best Practices, and Action Steps for States (U.S. EPA, 2006).

[3] As noted in Chapter 1, while clean energy resources include energy efficiency and energy resources that reduces demand for electricity and fossil fuels, the focus of this Resource is on those that affect electricity demand and/or the electric system.

[4] The actual impact of incremental renewable energy production on the energy system as a whole is complex and depends on factors such as the timing of production and the baseload requirements of the power grid. These energy system impacts are discussed in Chapter 3.

RETROSPECTIVE VERSUS PROSPECTIVE CALCULATION OF ENERGY SAVINGS

States can assess energy impacts from two perspectives: retrospectively, to evaluate impacts of existing investments, or prospectively, to plan new or modified initiatives. This *Resource* describes prospective techniques for estimating energy savings or renewable energy generation to help states plan: that is, methods and models that calculate energy impacts expected to occur in the future as a result of the state's proposed clean energy initiatives. Prospective analyses of energy impacts are appropriate, for example, when a state wants to gain support for a proposed clean energy policy, is assessing the relative costs and benefits of alternative policies in order to select the most cost-effective clean energy approach, or is determining the budget level required to meet clean energy goals.

A retrospective approach, in contrast, is based on measurements of actual impacts that have already accrued from the state's clean energy actions. Actual energy savings from energy efficiency programs, for example, are calculated using "measurement and verification" (M&V) methods, whereby measurements determine actual savings from measures implemented within an individual facility. Energy savings are calculated using the following approach:

- Select a representative sample of projects.

- Determine the savings of each project in the sample, based on deemed savings values (i.e., claimed savings) or measured savings, energy bills, or calibrated computer simulation.

- Apply the sample project's savings to the entire population (e.g., the clean energy program).

More information about retrospective calculation of energy savings from energy efficiency is available in the National Action Plan for Energy Efficiency (NAPEE), *Model Energy Efficiency Program Impact Evaluation Guide*, November 2007 (*http://www.epa.gov/cleanenergy/documents/evaluation_guide.pdf*) and U.S. EPA *Lead by Example Guide*, June 2009 (*http://www.epa.gov/statelocalclimate/resources/example.html*).

These direct energy supply impact estimates are the foundation for calculating potential cost savings and other benefits to the state economy, energy system benefits, and environmental and public health benefits.

2.2 HOW CAN STATES ESTIMATE THE POTENTIAL DIRECT ENERGY IMPACTS OF CLEAN ENERGY POLICIES?

There are four primary steps for estimating the potential direct energy impacts from clean energy policies (see Figure 2.2.1). The first step is to establish a BAU forecast of energy supply and demand. This involves taking a look at the historical demand and supply

portfolio within a state (i.e., developing the baseline) and projecting it forward, based on assumptions about the future. The projection is a BAU forecast that illustrates what state energy demand, consumption, and supply will most likely be in the absence of additional clean energy policies beyond those already considered in resource planning.

This projection can be used in a second step to develop or quantify the implications of an energy-related target if a state is interested.

The third step is to estimate the energy savings (or clean energy supply) from a proposed clean energy initiative or portfolio of initiatives. The energy savings are determined by estimating the impact on energy consumption levels and patterns of a specific policy approach, or the energy output from renewable resources.

The fourth step, creating an alternative policy forecast, allows the state to consider potential outcomes of realizing the direct energy impacts. In the case of efficiency, the energy savings estimates are subtracted from the BAU forecast developed under Step 1 to create a new energy forecast. For clean energy supply alternatives, the impacts estimates are used to assess impacts on the electric power system (in terms of what is displaced that otherwise would have been operated).

Because there are so many details and assumptions involved in estimating savings and creating alternative policies, a state must choose the right approach for the decision process at hand. As described below, the level of available resources (including budget, personnel, and data) often guides which approach to select when developing an energy savings estimate. For a quick comparison of policy alternatives, a top-down approach may be acceptable, while a bottom-up approach may be more appropriate for program planning and budget setting.

Each step is described below.

2.2.1 STEP 1: DEVELOP A BUSINESS-AS-USUAL ENERGY FORECAST

An energy baseline and BAU forecast documents the historical, current, and projected pattern of energy supply and demand within a state. The BAU forecast illustrates what state energy use will look like in the future, in the absence of additional policies beyond those already in place and planned. It typically includes current programs, such as regulations, standards, or energy efficiency programs. The BAU forecast is a reference case against which to measure the energy impacts of policy initiatives or unexpected system shocks (e.g., severe weather-related disruptions in energy supply).

As presented in Figure 2.2.2, the following six broad steps are involved in developing a BAU energy forecast:

1. Define objectives and parameters;

2. Develop a historical energy baseline;

3. Choose method to develop the forecast or project the historical energy baseline into the future;

4. Determine assumptions and review data;

5. Apply the chosen model or approach; and

6. Evaluate forecast output.

These six steps are described below.

STEP 1.1: Define Objectives and Parameters

For this chapter's purposes, the objective of the BAU forecast is to aid in determining energy savings from clean energy initiatives by offering a current and projected energy picture. To this end, states should:

- Determine if the forecast will be short- or long-term, and end-use based or sector-wide (i.e., explicitly modeling the building stock and end-use equipment vs. using a top-down model of the total sectoral or economy-wide demand);

- Establish the level of rigor necessary;

- Consider the availability of financial, labor, and time resources to complete the forecast; and

- Verify the amount of energy data readily available to develop the forecast.

These factors will help states choose between basic and more sophisticated forecasting approaches.

STEP 1.2: Develop a Historical Baseline

A comprehensive energy baseline includes the following historical energy data:

- Consumption (demand) by sector or fuel, and

- Energy generation (supply) by fuel and/or technology.

Consumption data are often broken down by the sectors that consume the fuels, including the commercial, residential, industrial, transportation, and utility sectors. This type of top-down baseline helps a state understand the large and small consumers within a state and helps target sectors for policy interventions. Each sector can also be further disaggregated to show the types of consumption within.

A top-down approach would be appropriate if a state plans to evaluate or quantify the requirements of a broad, state-wide energy efficiency or renewable energy goal. For example, in 2006, Wisconsin Governor Jim Doyle launched the *Declaration of Energy Independence,* which included a goal of using renewable energy to generate 25 percent of the state's electricity and 25 percent of its transportation fuels by 2025 (the "25x25" goal). Figure 2.2.3 illustrates a demand baseline by sector that the Wisconsin Office of Energy Independence developed to help it understand implications for energy consumption as it strives to achieve its goal. This top-down baseline helped the state understand how its total energy consumption (i.e., electricity, natural gas, petroleum, coal, and renewable energy use) is spread across sectors and identify which sectors seem most appropriate for further investigation and potential program intervention (Wisconsin, 2007).

An alternative or a complement to the top-down approach is to develop a bottom-up baseline. A bottom-up baseline is very data-intensive, but provides more information about activities within a particular sector than an aggregated, top-down baseline that is used to reveal trends and opportunities across sectors.

The bottom-up approach is most appropriate if a state is exploring a sector- or technology-specific clean energy policy. For example, if Wisconsin targets the residential sector to help achieve its 25x25 goal, the state could develop a bottom-up baseline that depicts the amount of residential consumption attributed to hot water heating, appliances, and cooling. If it finds that the majority of residential consumption is related to specific end-use equipment, it might focus its program design efforts on the most cost-effective and efficacious opportunities for equipment within the residential sector.

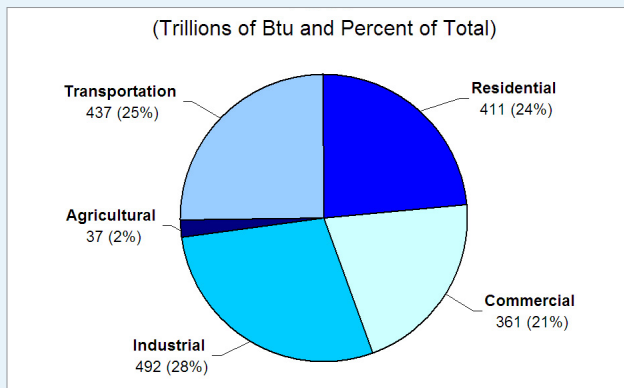It is important to recognize that both past and future demand for energy are products of the economic and weather conditions of the state as well as the types and

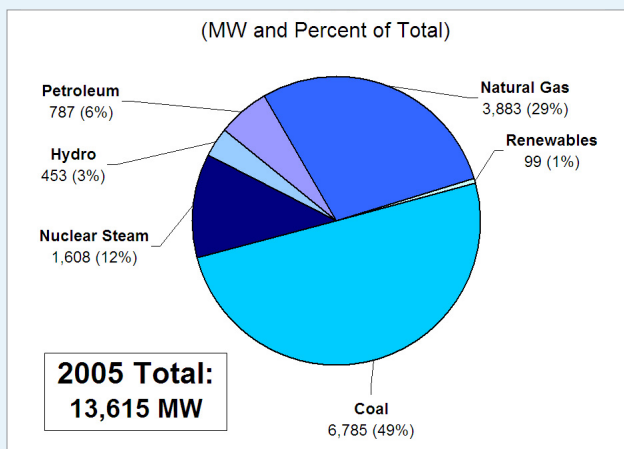## FIGURE 2.2.2   SAMPLE FRAMEWORK FOR DEVELOPING AN ENERGY FORECAST
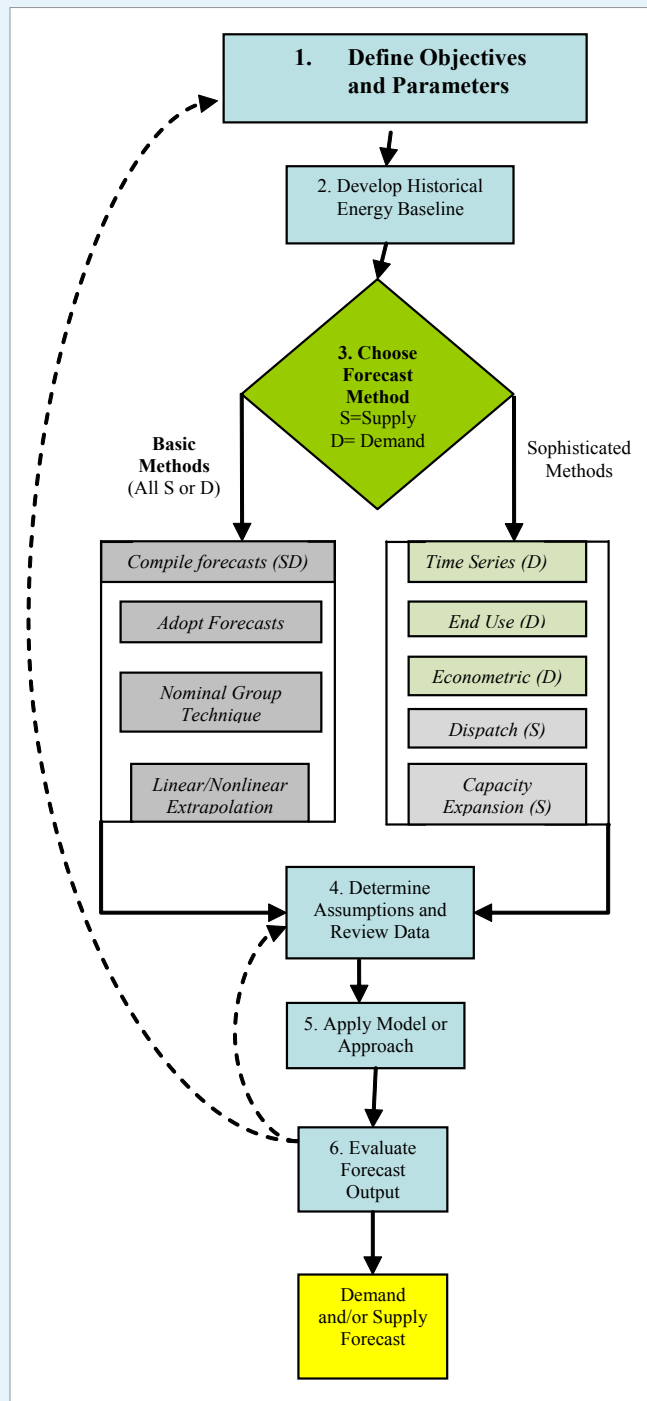
efficiencies of end-use appliances and equipment. Thus, future forecasts often need a specific economic projection as a starting point and should assume normal weather conditions.

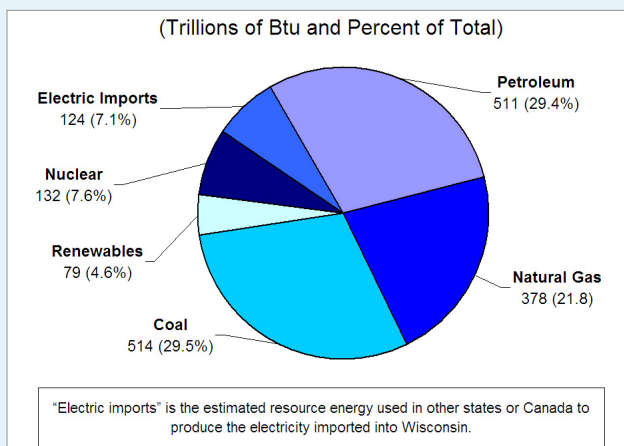## FIGURE 2.2.3   WISCONSIN RESOURCE ENERGY CONSUMPTION BY ECONOMIC SECTOR

(Trillions of Btu and Percent of Total)

Transportation 437 (25%)
Residential 411 (24%)
Agricultural 37 (2%)
Commercial 361 (21%)
Industrial 492 (28%)

Source: 2007 Wisconsin Energy Statistics, Wisconsin Office of Energy Independence, Achieving 25x25, page 8.

FIGURE 2.2.4   WISCONSIN ELECTRIC UTILITY GENERATING CAPACITY BY TYPE OF PLANT, 2005

(MW and Percent of Total)

Petroleum 787 (6%)
Natural Gas 3,883 (29%)
Hydro 453 (3%)
Renewables 99 (1%)
Nuclear Steam 1,608 (12%)
Coal 6,785 (49%)

2005 Total: 13,615 MW

Source: 2007 Wisconsin Energy Statistics, Wisconsin Office of Energy Independence, Achieving 25x25, page 52.

FIGURE 2.2.5   WISCONSIN RESOURCE ENERGY CONSUMPTION, BY TYPE OF FUEL, 2006

(Trillions of Btu and Percent of Total)

Electric Imports 124 (7.1%)
Petroleum 511 (29.4%)
Nuclear 132 (7.6%)
Renewables 79 (4.6%)
Natural Gas 378 (21.8)
Coal 514 (29.5%)

"Electric imports" is the estimated resource energy used in other states or Canada to produce the electricity imported into Wisconsin.

Source: 2007 Wisconsin Energy Statistics, Wisconsin Office of Energy Independence, Achieving 25x25, page 6.

On the **supply side,** electricity generation data can also be categorized by fuel type and sector.[5] Figure 2.2.4 illustrates Wisconsin's supply side baseline that shows electricity generation by type of fuel for a single year. A baseline energy forecast requires data about the types and amounts of fuel used to generate electricity, including uranium; coal; natural gas; municipal solid waste; wood; landfill gas; hydro; and petroleum fuels, such as distillates and residuals. Depending on a state's definition of "renewable," renewable fuels can include wood, landfill gas, pyrolysis liquid/gas, geothermal, hydro, solar PV/thermal, wind, and municipal solid waste.

Electricity generation data typically include electricity generation that has occurred within the state and, in order to be consistent with in-state consumption, it may reflect electricity imports and exports. It also accounts for transmission and distribution losses.

Consumption and/or generation-related baseline data can be obtained from many sources, including:

- State energy offices and departments of transportation (Figure 2.2.5 provides an example of energy consumption by fuel type data collected by the state of Wisconsin Office of Energy Independence),

- Consumer energy use profiles by sector,

- Utility Integrated Resource Planning (IRP) filings,

- Public utility commissions,

- Independent system operators (ISOs),

- North American Electric Reliability Corporation (NERC),

- EPA's Emissions & Generation Resource Integrated Database (eGRID) ,

- DOE's Energy Information Administration (EIA), and

- DOE's National Renewable Energy Laboratory (NREL).

As shown in Table 2.2.1, these sources provide a variety of different types of data, including historical and projected supply and demand for electricity, natural gas, and other fuels (discussed in the next section).

---

[5] *Local energy baselines can focus on end-use sectors (i.e., residential, commercial, industrial, and transportation) and allocate the fuel used to generate electricity across the sectors that consumed the electricity.*

STEP 1.3: Review and Select Method to Forecast the Business-as-Usual Case

States can use basic or sophisticated modeling approaches to forecast their business-as-usual energy cases and predict energy supply and demand. Both approaches are based on expectations of future population changes, energy data, and economics.

Basic methods may require a state to (1) adopt assumptions made by utilities, independent system operators,

and regulatory agencies about the projected population, energy situation, and the economy; or (2) compile and develop its own assumptions. Basic approaches are generally appropriate when conducting screening analyses or developing highly aggregated forecasts when the amount of time or funding to support a forecast is limited or when the time period of the forecast is short.

More sophisticated methods can be used for short-term or long-term analyses. They provide greater detail

TABLE 2.2.1 SAMPLE ENERGY DATA SOURCES FOR DEVELOPING BASELINES AND BAU FORECASTS

Sources	Electric		Natural Gas		Other Fuels		Description
	Historic	Forecast	Historic	Forecast	Historic	Forecast	
State Sources							
Consumer energy profiles (residential, commercial, industrial)	X		X		X		Most utilities conduct audits, surveys, or EE evaluation studies as part of energy efficiency programs' regular reporting. Data are customer-specific load profiles that can be used to build up total demand.
State Energy, Utility Commissions, Transportation, or other Offices	X	X	X	X	X	X	Most states collect historical and forecast data for both supply and demand information. Other agencies may have compiled similar energy information that could be used for this effort.
Utility-Related Sources							
Utilities	X	X	X	X	X	X	Most utilities collect historical and forecast data. Make sure documentation is collected as well, so that limitations can be understood—what's in and what's not, for example.
Consumer energy profiles (residential, commercial, industrial)	X		X		X		Most utilities conduct audits or EE evaluation studies as part of energy efficiency programs' regular reporting. Data are customer-specific load profiles that can be used to build up total demand.
Public Utility Commissions	X	X	X	X	X	X	Most PUCs collect historical and forecast data. Usually are supplied from utilities and studies. Use to collect supply and demand data.
Independent System Operators/ RTOs	X	X					Supply and total demand information to be used for planning purposes. Available from the Midwest Independent System Operator (ISO), ISO-New England, Pennsylvania-New Jersey Maryland Interconnection, Southwest Power Pool, California ISO, Electric Reliability Council of Texas, Florida Reliability Coordinating Council, and New York Independent System Operator.
North American Electric Reliability Corporation (NERC) Electricity Supply and Demand Database	X	X					Capacity and demand, up to 10-year projections of electricity demand, electric generating capacity, and transmission line mileage. Generation data include unit-level statistics on existing generators, planned generator additions and retirements, and proposed equipment modifications. Free to government agencies. *http://www.nerc.com/page.php?cid=4|38*

TABLE 2.2.1 SAMPLE ENERGY DATA SOURCES FOR DEVELOPING BASELINES AND BAU FORECAST *(cont.)*

Sources	Electric		Natural Gas		Other Fuels		Description
	Historic	Forecast	Historic	Forecast	Historic	Forecast	
Federal Agency Sources							
EIA Electric Power Annual	X						National, some regional and state level capacity and demand, margin, energy retail sales (MWh), revenue, emissions, short term plans, etc. http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html
EIA State Energy Profile, State Energy Data (SEDS)	X		X		X		Annual production, consumption, prices, and expenditures by energy source. http://tonto.eia.doe.gov/state/ http://www.eia.doe.gov/cneaf/electricity/epm/table1_6_a.html http://www.eia.doe.gov/emeu/states/_seds.html
EIA Electric Sales, Revenue, and Price tables or EIA Annual Electric Utility data—EIA-860, 906, 861 data file	X						Annual data, peak, generation, demand/consumption, revenues, utility type, and state. http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html http://www.eia.doe.gov/cneaf/electricity/page/eia861.html http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html
EIA Manufacturing Energy Consumption Survey (MECS); Commercial (CBECS); Residential (RECS)	X		X		X		A national sample survey on the stock of U.S. buildings, their energy-related building characteristics, consumption (by appliance) and expenditures. http://www.eia.doe.gov/emeu/mecs/contents.html http://www.eia.doe.gov/emeu/cbecs/ http://www.eia.doe.gov/emeu/recs/contents.html
EIA Annual Energy Outlook	X	X	X	X	X	X	National forecast of supply and demand. http://www.eia.doe.gov/oiaf/aeo/
EPA Emissions & Generation Resource Integrated Database (eGRID)	X						http://www.epa.gov/egrid for supply planning.
NREL	X		X	X	X	X	Data on various renewable energy technologies and some costs. http://www.nrel.gov/rredc/

than the basic methods, and can capture the complex interactions within the electricity and/or energy system. Some states might want to consider a more sophisticated modeling approach for their demand and supply forecasts in cases where:

- They want to better understand the effects of demand growth on their required portfolio of supply resources in the future, or

- They want to analyze the effects on energy demand and supply of significant changes that have occurred or are expected to occur in economic patterns (e.g., a dramatic decrease in housing starts) or energy costs.

Sophisticated approaches are often data-, time-, and labor-intensive; lack transparency; may involve model licensing and data fees; and require a significant commitment of staff resources to develop expertise in the

TABLE 2.2.2 COMPARISON OF BASIC METHODS FOR FORECASTING ENERGY DEMAND AND SUPPLY

Methods	Advantages	Disadvantages	When to use
Compilation of individual forecasts by others	Easy to gather	Driven by different assumptions that may no longer apply; proprietary concerns; possible short horizons; may or may not provide information on construction requirements, fuel use, emissions, and costs; gaps in coverage.	High level, preliminary and quick analysis.
Adoption of a complete forecast used by others	Easiest method	May not have the long-term outlook. Assumptions may not comport with desired state/regional outlook. May require translation to alternative geographic scope. May be proprietary.	High level, preliminary and quick analysis.
Nominal Group Techniques (NGT)	Consensus building	Time-consuming and relatively expensive.	Adequate budget and stakeholder interest.
Linear and/or Nonlinear Extrapolation of Baseline	Quick	May not capture impact of significant changes (e.g., plant retirements).	High level with simple escalation factors from history or from other sources.
	More robust data analysis	Possible errors in formulas, inaccurate representation of demand and supply.	Knowledge of generation dispatch by type of plant.

model. Unless the tool is used for broader or multiple analyses (e.g., statewide energy planning), it may be impractical for the state to build the capacity to run these models in-house. However, most models are supported by one or more consultants who have readily available supporting data and who may be retained for these types of specialized studies.

This section provides information about basic and sophisticated approaches, methods under each approach, data needs, and the respective advantages and disadvantages of each of the methods.

Basic Forecast Methods: Demand and Supply

States can use a range of basic methods to project their BAU energy without using rigorous, complicated analyses and software models. These methods generally produce aggregate information about a state's energy future, perhaps with a larger margin of error than more sophisticated approaches.

Basic approaches for forecasting energy demand and supply include: (1) compilation of partial forecasts (e.g., utility service territory) by others into one state

forecast; (2) adoption of a pre-existing forecast that someone else may have developed for the state; (3) group consensus-building processes to develop assumptions used within a forecast; and (4) extrapolation of historical rates of demand growth and electricity production (or rates of growth from other forecasts) that are applied to the baseline. Table 2.2.2 summarizes the advantages and disadvantages of each approach and describes the most appropriate uses of these approaches. Each approach is explained in greater detail below.

- *Compilation of individual forecasts by others*: Energy plans from utilities, ISOs, and regulatory agencies often include a demand forecast that reflects energy savings from energy efficiency programs. Similarly, a corresponding supply plan is likely to include data on existing and projected renewable energy sources, including combined heat and power plants, if significant. States can aggregate individual load forecasts, generation expansion plans, and energy efficiency programs and renewable energy evaluations from state agencies, utilities, ISOs, local educational institutions, and special interest groups, such as interveners in rate cases. Compiling forecasts created by different entities can be

challenging, because they can vary significantly from each other in terms of underlying assumptions, proprietary concerns, data transparency (e.g., unit generation, costs), and time frame.

- *Adoption of a forecast used by others:* In some states, an energy office, utility commission, revenue department, or academic organization may have prepared a suitable energy forecast. Also, utilities and ISOs may have forecast plans. A regulatory filing requirement (e.g., Integrated Resource Plan) typically provides a comprehensive long-term plan that includes impacts from energy efficiency; reliable demand response, if any; and existing renewable energy plans.[6] However, there may be proprietary constraints to obtaining this information and these forecasts may reflect economic conditions that differ from the state's view.

- *Nominal Group Techniques (NGTs)* are structured group processes (similar to "voting") to form consensus opinions, including expectations for the future. They can be used to develop forecasts or to develop inputs to the preceding methods or more complex models. The type most commonly used in forecasting is the Delphi method. A more recent approach, called Deliberative Polling, might be useful for this purpose, but it is expensive and time-consuming. Working with multiple stakeholders does provide value overall; however, this approach loses detail when valuing the impacts of changes. [7]

- *Linear/Non Linear Extrapolation* involves spreadsheet analysis where historical demand growth rates and electricity production trends (or trends from an alternative forecast) are used to extrapolate base year data into the future. The accuracy of this approach depends on the accuracy of the "borrowed" growth rates, and the knowledge and experience of the analyst when applying historical trends. An advantage to this approach is that it is easy to develop in a spreadsheet and use for preliminary forecasting. A disadvantage is that the exclusion of important variables beyond demand growth factors and electricity—such as weather; season; plant retirements or construction,

operation, or capital costs; emissions; or macroeconomic growth—may result in an inaccurate forecast. Figure 2.2.6 illustrates a simple example of a linear extrapolation analysis.

Sophisticated Forecast Methods

States may develop supply and demand forecasts using one of the basic approaches described above, based on the perception that the demand rate will probably follow historical trends. Alternatively, they might want to consider a more sophisticated modeling approach when they require a more comprehensive understanding of their energy profile or when they have experienced or expect to experience significant changes in their energy or economic patterns.

Sophisticated methods involve data- and resource-intensive computer-based models that generate detailed forecasts that may reflect historical trends, economic and/or engineering relationships, future expectations about prices, technologies and technology development, operating constraints, and regulatory

---

FIGURE 2.2.6   NEW JERSEY ENERGY PLAN-BASIC DEMAND FORECAST
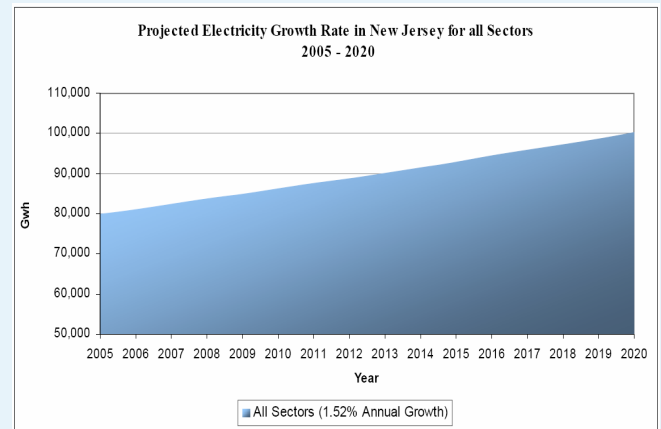
This BAU electricity forecast was developed using a relatively simple approach in which past load growth rates were reviewed and assumptions were made regarding the ways in which industry trends and existing policies affect future growth patterns. While recent growth rates (1998 to 2004) had been in the range of 2% annually, the average annual growth rate since 1990 was only 1.52%. The New Jersey Board of Public utilities chose to carry forward the long term 1.52% growth rate based on the assumption that demand growth would level out once electricity prices increase after the deregulation rate caps expire.

Source: New Jersey, 2008.

---

6   For information about how utilities integrate energy efficiency into resource planning, see *The Guide to Resource Planning with Energy Efficiency: A Resource of the National Action Plan for Energy Efficiency, November 2007.* www.epa.gov/cleanenergy/documents/resource_planning.pdf

7   In Vermont, a similar approach was used through a public workshop process in which electric industry stakeholders provided their input on the state's energy plan.

expectations (e.g., environmental regulations). While basic forecast methods are applied similarly to demand and supply forecasts, sophisticated approaches generate separate demand and supply forecasts that can be integrated once developed. As such, sophisticated methods for developing demand and supply forecasts are described separately below.

Demand Forecast

Once the historical baseline is developed, states can develop an energy demand forecast using time series, end use, or econometric models. These types of models can be used for short- and long-term load forecasting, comprehensive load analysis, modeling, and "day-after" settlement. Each model, and its advantages and disadvantages, is described below.

- **Time-Series Models** are based on the assumption that the data (and the variable being forecast) have a structure or pattern, such as a trend and/or seasonal variation. Future events are forecast based on known past events and patterns. Inputs require an analysis of historical patterns in demand for electricity. This analysis can be a simple look at the aggregate demand and a forecast based on the pattern of this demand, or a breakdown of the demand into customer type (e.g., residential, commercial, industrial) and application of each cyclical pattern over time to develop the total demand forecast.

  Advantages of time-series models are:

  ‣ These models are easy and fast to use; and

  ‣ Historical data are widely available by year, fuel, end use, or sector (residential, commercial, and industrial).

  Disadvantages of time-series models are:

  ‣ Data may relate to a historical baseline that has undergone major structural changes, such as a switch from heavy manufacturing to high-technology industries, that are unlikely to occur again, thus complicating or invalidating the forecast;

  ‣ It is hard to reflect future structural changes even if they are anticipated; and

  ‣ Time-series models cannot reflect supply-demand-price feedbacks dynamically.

- **End-Use Models** develop the load profiles of each customer type by analyzing the historical consumption of appliances and equipment (including any existing DSM programs) and may use specific surveys from customers about future growth and contraction. This approach can also include an economic forecast that provides gross state product (GSP) and consumer electricity prices.

  ‣ An advantage is that this approach uses a load profile for each customer class being served, providing a reasonable estimate of demand.

  ‣ A disadvantage is that it can require considerable time and cost to collect the data. Users can elect to use project-specific models to help assess building demand estimates.

- **Econometric Models** provide a more complex and robust analysis that uses inputs such as inflation, demographics, gross state product, consumer energy prices, gross/disposable income, housing starts, business starts/failures, birth/death rates, surveys of business expansion plans, historical energy consumption, and other variables for structural changes and economic data. The model output includes data correlations, or relationships, between demand and energy consumption. For example, the output may show that as income increases, energy demand increases. These relationships can be applied in detailed demand and energy consumption forecasting. Econometric methods are sometimes used in combination with end-use methods.

  ‣ An advantage of this method is that it creates a robust demand forecast if driven with a robust economic forecast.

  ‣ A disadvantage is the time and cost required to prepare the inputs and review the results.

- Some examples of these models in use include ENERGY 2020 and EPRI's suite of tools. ENERGY 2020 is an end-use-econometric energy market model used for forecasting demand and supply across all fuels and sectors. It has been used in Illinois, Massachusetts, and Hawaii for long-term forecasting. EPRI's suite of bottom-up, end use forecasting models, such as the Residential End Use Energy Planning System (REEPS) and the Commercial End Use Planning System, are used primarily by utilities. Some states have developed their own models. For example, California has developed end use (residential) and econometric (commercial) models for forecasting.

Supply Forecast

Utilities, ISOs, and other sophisticated energy market participants use supply forecast models for hourly, daily, monthly, and long-term forecasting. Sophisticated supply forecasting models require large volumes of data on electricity production plants, transmission capabilities, and a demand forecast—and the better the quality of that data, the better the results. Although the costs to acquire the software and data may be prohibitive for some users, these models generally provide more robust estimates on energy and capacity output than basic modeling approaches. Models covering both electricity dispatch modeling and capacity expansion (or planning) modeling are summarized in Table 2.2.3.

■ *Electricity Dispatch models* (also commonly referred to as "production cost" models) simulate the dynamic operation of the electric system, generally on a least-cost system dispatch. In general, these models optimize the dispatch of the system based on the variable costs of each resource and any operational constraints that have been entered into the model. These models are helpful in assessing which existing plants[8] are displaced. These models

---

8   *These dispatch, or production costing models focus on existing plants or a specified portfolio of plants (which may contain some new or proposed plants); however, these models only produce estimates of avoided variable costs and changes in the output of different resources. Changes in the use of a resource (e.g., a marginal coal-fired power plant) are key inputs into any modeling of changes in emissions due to EE or RE activities. These dispatch models do not internally examine changes in the capital costs (e.g., avoided capital costs) that might result from investments in EE or RE. However, this can be done through spreadsheet models that have been developed to augment electricity dispatch models or using models that combine capacity expansion and dispatch (e.g., NEMS, IPM).*

TABLE 2.2.3   EXAMPLES OF SOPHISTICATED SUPPLY FORECASTING MODELS

Sampling of models	Advantages	Disadvantages	When to Use this Method
Electricity Dispatch			
■ PROSYM™ ■ GE MAPS™ ■ PROMOD IV® ■ MIDAS[a]	■ Can provide very detailed estimates of specific plant and plant-type effects within the electric sector. ■ Provides highly detailed, geographically specific, hourly data.	■ Often lacks transparency. ■ Labor- and time- intensive. ■ Often high labor and software licensing costs. ■ Requires establishment of specific operational profile of the clean energy resource.	■ Often used for evaluating: ■ Specific projects in small geographic areas, ■ Short-term planning (0-5 years), and ■ Regulatory proceedings.
Capacity Expansion or Planning			
■ NEMS ■ IPM® ■ ENERGY 2020 ■ LEAP ■ Strategist® ■ Plexos® ■ EGEAS ■ AURORAxmp ■ MARKAL-MACRO[b] ■ Ventyx System Optimizer	■ Model selects optimal changes to the resource mix based on energy system infrastructure. ■ May capture the complex interactions and feedbacks that occur among demand, environmental, fuel, electric markets. ■ Provides estimates of emission reductions from changes to the electricity production and/or capacity mix. ■ May provide unit-specific detail (IPM).	■ Requires assumptions that have large impact on outputs. ■ May require significant technical experience. ■ Often lacks transparency. ■ Labor- and time- intensive. ■ Often high labor and software licensing costs.	■ Long-term studies (5-25 years) over large geographical areas. such as: ■ State Implementation Plans, ■ Late-stage resource planning, ■ Statewide energy plans, and ■ Greenhouse gas mitigation plans.

ᵃ *Ventyx markets the MIDAS solution as a strategic planning tool since it incorporates Monte Carlo capabilities. This tool is included in the list of electricity dispatch models, as it generally uses a pre-selected set of resource plans and the MIDAS model focuses on electricity price forecasting and financial analyses (e.g., balance sheet analyses) of each resource plan.*

ᵇ *MARKAL-MACRO model is represented as multipurpose energy planning model, http://www.etsap.org/Tools/MARKAL.htm.*

are also used in short-term planning and regulatory support.

Advantages of electricity dispatch models are:

‣ These models are often used in generation project financial analyses, since they provide forecasts of wholesale electric prices for each hour (i.e., system marginal costs) and the hourly operations of each unit. By comparing the variable costs of each unit with the price forecasts, an estimate of plant profitability can be developed.

‣ They can be run to develop a BAU and multiple sensitivity cases to assess the impact on various planning parameters (e.g., transmission, plant dispatch, and avoided variable costs), and may capture complex interactions and tradeoffs.

‣ Electricity dispatch models are usually more detailed in their specification of operational and variable costs compared with capacity expansion models.

‣ These models are ideally suited for estimating wholesale electric prices (i.e., the marginal system cost) and the hours of operation and production of each unit in the system for up to a five-year time frame. This information has been the basis for plant financing decisions and the development of unit operating and bid strategies in markets. In these roles, the electricity dispatch model is viewed as a superior tool. These same data also are necessary in estimating the emissions of specific units and the regional electric system being modeled.

Disadvantages of electricity dispatch models are:

‣ These models cannot estimate avoided capacity costs from EE or RE investments. Unlike the capacity expansion models described below, these costs must be calculated outside the electricity dispatch model using a spreadsheet model or other calculations.

‣ Some of these models require substantial detail on each unit in a regional electric system and are typically full chronologic models (i.e., some data elements are needed for all 8,760 hours in a year).

‣ The complexity of these models often results in agencies and stakeholders working with utilities to coordinate the application of the models in policy analyses and in regulatory proceedings.

‣ Electricity dispatch models can also be effectively used to develop estimates of generation impacts of long-term resource plans, but they require considerable side calculations in terms of the explicit specification of projected new units that constitute a limited number of "build scenarios" and the computation of the capital costs of the system to augment the variable costs produced internally by the electricity dispatch models.

▪ *Capacity Expansion or Planning models* are designed to make decisions on how the electric system adds new capacity to meet future demand over a 20- to 25-year planning period. This differs from the primary role of electricity dispatch models, which is to develop electricity price forecasts, the hours of operation, the electricity output for specific units, and the revenues and profits for generation units in a regional system. In contrast, capacity expansion models evaluate the economics of potential new generating unit additions to the system (some models allowing a great deal of specificity with respect to new unit options). Capacity expansion models use information on demand growth, regional electric system operations, and the characteristics of candidate new units, typically within an optimization framework, that selects a future build-out of the system (multiple new units over a 20- to 25-year time frame) that has the lowest overall net present value (NPV), taking into account both capacity and variable costs of each unit. This simulated build-out can include the retirement of existing units, selection of base load capacity, and decisions to build peaking capacity that minimizes the NPV over the 20- to 25-year planning scenario.

Many capacity expansion models have some representation of system dispatch. Dispatch modeling in these combined capacity expansion and dispatch models may not be based on an 8,760 hourly structure, but instead dispatch to more aggregated load segment curves representing seasonal energy demand by load segments (e.g., peak, intermediate segments, and base load). These types of models include IPM® and NEMS.

Advantages of capacity expansion models are:

- They are designed to incorporate a number of factors that are influenced by changing policies, regulatory regimes, or market dynamics (e.g., stricter emission policy, introduction of a renewable portfolio standard).

- While both electricity dispatch models and capacity expansion models are used in IRP proceedings, the capacity planning model is designed specifically to develop long-term resource plans.

- Capacity expansion models are able to estimate avoided capacity costs and usually also produce estimates of avoided variable costs.

Disadvantages of capacity expansion models are:

- The complexity of these models often results in agencies and stakeholders working with utilities to coordinate the application of these models in policy analyses and in regulatory proceedings.

STEP 1.4: Determine Assumptions and Review Data

After choosing the forecasting approach or model type, the next step is to determine or review assumptions about population, energy, and economic variables, such as energy prices, productivity, gross state product, and the labor force upon which projections of energy demand and supply depend.

It is also important to review possible data sources and collect the data required for the analysis. The following types of data are used in estimating energy consumption and supply baselines and forecasts:

- States can use **population data** to estimate the amount and types of demand expected in the future and to examine trends. The U.S. Census Population Estimates Program provides historical and projected population data (*http://www.census. gov/popest/estimates.php*).

- A forecast depends upon assumptions about the economy that the analyst projects into the future. States can examine **economic variables** as they relate to energy in order to better understand the historical relationships between energy and the economy, and to anticipate how these relationships

may exist in the future. The Bureau of Economic Analysis (*http://www.bea.gov/*), Bureau of Labor and Statistics (*http://www.bls.gov/*), and the U.S. Census Economic Census (*http://www.census.gov/ econ/census02/*) all provide macroeconomic data that states can use.

- The forecast may require assumptions about the **energy and fuel prices** the state should expect in the future. EIA provides regional energy and fuel price forecasts out to 2030 (*http://www.eia.doe. gov/oiaf/forecasting.html*). Price projections may also be available from PUCs and ISOs, although proprietary constraints may limit the amount available. In addition, a number of private data providers may be able to offer data that are more recent than those from publicly available sources.

Almost all providers of electricity dispatch and capacity expansion models also offer a data set that can be used to apply these models to a regional electric system. Data from any source must be examined to ensure that they are consistent with the assumptions of the entities that will use the model results, and to check for outliers, errors, and inconsistencies in the data. No data set from any source is guaranteed to be fully appropriate to a user's needs, and any data set may contain errors.

At this point in the process, it may also be necessary to clean the data and/or fill in any missing data gaps. If data points are missing for particular years, it may be necessary to interpolate the existing data or use judgment to fill in gaps. This will minimize the likelihood of generating results based on calculations that are skewed due to missing or out-of-range data, producing a forecast that would then not make sense. Some of the private data providers also provide data cleaning services. Practical application of any of these data bases, however, requires due diligence in looking for data outliers, missing values, and screening for errors in data. It is a rare occurrence for a user to obtain a fully clean data set, consistent with their individual assumptions, from any one source.

STEP 1.5: Apply Model or Approach

States can apply the selected model or approach to the historical baseline energy data based on the assumptions about future population, economic, and energy expectations. It is important to revisit the assumptions and data that will be required for the specific model requirements to assure that they are still valid. As mentioned in earlier sections, many state agencies and stakeholders work with utilities or consultants to actually perform

the model runs. Still, it is important to have transparency around the model inputs and the policy/regulatory assumptions incorporated into the model, as well as a solid understanding of the basic operations of the model (i.e., the algorithms used to produce the model outputs).

STEP 1.6: Evaluate Forecast Output

Once generated, it is important to evaluate the forecast to ensure that it is reasonable and meets the original objectives. If the state determines that some or the entire forecast does not seem realistic, it may need to revisit assumptions and then re-apply the approach or model to achieve an acceptable demand forecast.

Issues and Considerations

When developing an energy baseline and BAU forecast, it is important to consider the following issues.

- Typically the data available for a baseline and BAU forecast lag several years. For this reason, the current and most recent years may be part of the forecast and not the history. It is important, therefore, to ensure that the data derived for recent years reflect the current energy supply and demand as much as possible.

- As with all analyses, transparency increases credibility. All sources and assumptions require documentation.

- When documenting an energy forecast, it is important to clearly state what activities will take place without any new clean energy initiatives (i.e. what is "in the baseline"). For example, many state forecasts assume that some level of energy-efficient actions or regulatory changes (e.g., GHG reduction requirements) will be implemented over time. It is important to avoid double-counting when examining future program potential or impacts.

2.2.2 STEP 2: QUANTIFY IMPLICATIONS OF TARGETS AND GOALS

If a state has or is considering a broad clean energy goal, it is helpful to estimate the potential implications of the goal before evaluating specific clean energy programs and implementation options. For example, the state may need to quantify—in terms of kWhs—the requirements of an energy efficiency goal or target. Suppose the policy or goal is to have zero growth in energy demand over the next 10-20 years; it would then be necessary to estimate how much energy efficiency

would be required to meet that goal. Alternatively, the state may need to quantify—again, in kWh terms—the implications of a renewable portfolio standard. These estimates will indicate how much energy must be saved each year, or how much clean energy must be provided.

While the energy implications of any goals should be checked against existing energy efficiency or renewable energy potential studies to make sure they are plausible, this type of estimate is not focused on estimating what is cost-effective, what the market might adopt, or when the specific technologies might be adopted; it only estimates what the goal or target implies.

Methods for these estimates can include both basic and sophisticated approaches, but these high-level estimates will most likely require only the most basic approaches as the focus is simply on quantifying the meaning of the goal (e.g., a 2 percent reduction in demand per year implies a savings of x kWh). Basic approaches typically start with a baseline forecast as developed under Step 1. This will be the primary determinant of energy savings or clean energy supply required. The exact methodology chosen, however, will depend on how the goal or target is specified and a host of other factors, such as whether the energy savings from efficiency are measured from the baseline forecast or from prior years' sales. Also, the extent to which existing programs do or do not count toward the target may affect the calculations. It is important to read (to the extent they are available) the details of the goal, policy, or legislation, then think through the implications of these details for the methodology and calculations.

Suppose a state is determining the anticipated energy savings or generation needed to achieve a clean energy initiative in a target year (e.g., the target is to build 100 MW of wind power capacity by 2020). If appropriate financial incentives are in place to encourage construction of the wind facility, the energy available in the year after 100 MW of wind facilities are placed in service can be estimated at a very basic level as:

$$100 \text{ MW} * 0.28 \text{ capacity factor}[9] * 8{,}760 \text{ hours/year} = 245{,}280 \text{ MWh/year}.$$

The important element here would be to ensure that the 28 percent capacity factor is applicable to the

---

[9] *Capacity factor is defined as the ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period. Typical capacity factors for wind range from 20 percent to 35 percent.*

wind resource being considered. The output of a wind turbine depends on the turbine's size and the wind's speed through the rotor, but also on the site's average wind speed and how often it blows. Data to assess appropriate capacity factors can be identified based on geographic data on wind class (speed).

Alternatively, suppose a state is considering an Energy Efficiency Portfolio Standard (EEPS) that calls for a 20 percent reduction in energy demand growth by 2020.

The state might estimate the annual implications of the policy as outlined below (with calculations illustrated in Table 2.2.4).

▪ First, a pathway, with annual targets, would be required to assure the 20 percent total reduction is reached. Table 2.2.4 shows one possible pathway.

▪ Next, this percent savings is applied to the BAU forecast (which was expected to increase by 3 percent per year prior to the EE initiative) in order to calculate EE savings required. The fourth column shows the EE savings required.

▪ Finally, the new target level of demand is shown. In this example, the results indicate a new lower demand annual average growth rate (AAGR) of 1.1 percent.

While the actual path that is followed or the estimates of achieved savings (e.g., for M&V purposes) may differ from those shown in this simple exercise, this type of calculation gives an indication of the implications for program requirements and the resulting impact on growth.

TABLE 2.2.4 EXAMPLE OF ESTIMATION OF REQUIRED EE SAVINGS BASED ON LONG TERM SAVINGS GOAL OR PERFORMANCE STANDARD (KWH)

	BAU Demand (3% AAGR)	% Required Savings off of BAU required	EE Savings Required	New Target Demand (New AAGR = 1.1%)
2008	1,000.0	0.5%	5.0	995.0
2009	1,030.0	1.0%	10.3	1,019.7
2010	1,060.9	1.5%	15.9	1,045.0
2011	1,092.7	3.5%	38.2	1,054.5
2012	1,125.5	5.5%	61.9	1,063.6
2013	1,159.3	7.5%	86.9	1,072.3
2014	1,194.1	9.5%	113.4	1,080.6
2015	1,229.9	11.5%	141.4	1,088.4
2016	1,266.8	13.5%	171.0	1,095.8
2017	1,304.8	15.5%	202.2	1,102.5
2018	1,343.9	17.5%	235.2	1,108.7
2019	1,384.2	19.5%	269.9	1,114.3
2020	1,425.8	20.0%	285.2	1,140.6

If the state has an emissions-related goal, this type of quick, top-down analysis can then be linked to emissions data to determine what portion of the state's emissions targets could be met with a specific percentage EEPS. Similar linkages could be made to economic or other impacts as well.

Considerations

There are a number of factors to consider when estimating the implications of targets and goals for electricity demand and resources:

- The baseline level of electricity demand and supply (described earlier in this chapter);

- Expected growth over time under BAU (described earlier), including any ongoing energy efficiency or renewable energy efforts that may or may not contribute to the new goal, but will influence baseline conditions;

- The likely persistence of energy efficiency savings over time (or changes in the supply of clean energy);

- Other considerations that may affect the level of savings or supply required, such as rebound effects in energy efficiency programs; and

- The remaining electricity demands (or supply) after the impacts occur.

Quantifying the implications of broad goals and targets typically requires straightforward mathematical calculations, as shown above, and do not usually involve sophisticated approaches. However, advanced modeling and economic analysis may be required if, for example, a goal or target is tied in some way to an economic indicator or requirement (e.g., if a goal or target has some circuit-breaker or threshold provision, for example, requiring that only energy efficiency costing less than a certain amount be required), or has some dynamic aspects to it (e.g., changing targets in response to achievements).

2.2.3 STEP 3: ESTIMATE POTENTIAL DIRECT ENERGY IMPACTS

A critical step in the process of assessing the multiple benefits of clean energy is the estimation of the potential direct energy impacts of clean energy programs or policies under consideration. Direct energy impacts include energy savings from energy efficiency initiatives

and electricity production from renewables and other clean energy supply options. These estimates are the foundation for estimating the multiple benefits of clean energy as described in the subsequent chapters of this *Resource*. For example, changes in energy consumption due to energy efficiency or energy output from clean resources are matched to characteristics of generation, as described in Chapters 3 and 4, to assess changes in costs, emissions, and other factors.

Potential direct energy impact estimates can be developed in the context of a target, but a target is not required to estimate these impacts. Here the state would be estimating the expected result of a policy or program that is under consideration and has been sufficiently defined to allow meaningful analysis. In the case of prospective programs and policies, the state is trying to assess whether the program or policy goals are achievable and at what costs, and what specific actions are required by market participants. For example, the state may be considering an RPS of 20 percent by the year 2020, and wants to understand what specific resources would have to be built to comply; or the state may have a goal of 10 percent reduction in residential energy demand in five years and wants to understand what programs it can implement to achieve that goal.

Examples of these types of impact estimates include:

- Estimating the impact of appliance standards in a way that considers the existing stock, current efficiency levels, and consumer decision making;

- Estimating the expected response to a utility energy efficiency program, with or without specific information on program focus (what sectors and end uses) and design issues (e.g., rebate levels); and

- Estimating the impact of a renewables incentive program.

Please see the text box *Programs For Which Energy Impacts Might Be Estimated* for program examples.

Similar to the process for developing an energy forecast, estimating the potential direct energy impacts involves a series of steps, including:

1. Define Objectives and Parameters,

2. Choose Method to Estimate Potential Direct Energy Impacts,

3. Determine Assumptions and Review Available Data,

4. Apply Model or Approach, and

5. Evaluate Output.

Each of the steps is described in greater detail below.

STEP 3.1: Define Objectives and Parameters

It is important to define the objectives and parameters of the direct energy impacts a state plans to estimate. If the objective is to quantify the required energy savings from a state's clean energy initiatives or goals to the state legislature, for example, the parameters of the analysis may already be dictated. For example, the legislature has likely specified a due date, a time period to be analyzed, and a reasonable level of rigor, and may even have required the state to spend a certain amount of money on the analysis. Other analyses, such as those conducted to screen a range of clean energy options based on their multiple benefits, may be less defined.

It is necessary to consider each of the following parameters before choosing an analysis method, model, or dataset(s) to use.

- *Time period for the direct energy impacts*: Is it a short-term or longer-term projection?

- *Timeliness of the estimates:* Is this due in a year or next week?

- *Level of rigor necessary to analyze policy impacts*: Is this for a screening study or a regulatory analysis that is likely to be heavily scrutinized?

- *Availability of financial, staff, and outside resources to complete the analysis in the required time period*: Is there a budget available for the analysis? Does the state have internal modeling capabilities?

- *Amount of data available, or that can readily be acquired, to develop the savings estimate*: Are there existing clean energy potential studies or similar projects elsewhere that can be adapted to a state analysis?

These factors will help states choose between simple and more rigorous approaches based upon specific needs and circumstances.

STEP 3.2: Choose Method to Estimate Potential Direct Energy Impacts: Energy Savings and Renewable Energy Generation

Several tools and methods are available to help states estimate the potential direct energy impacts of clean energy options. States can conduct their own surveys or studies to estimate the direct energy impacts of clean energy policies and use sophisticated methods, such as applying building simulation tools, vintaging models, and production costing models. Because new surveys and studies tend to be costly and time-consuming, however, states often use those that have already been done by utilities, trade groups, other states, or the federal government, and adapt them to reflect the circumstances of the state. It is likely that states will need to use a combination of both existing and new analyses, since existing data sources and studies must be supplemented with complete and up-to-date data for specific populations and measures that can be difficult to obtain without additional targeted research.

Estimates typically factor in several considerations, including:

- the characteristics of the customer base and the existing equipment stock,

- the economics of the clean energy options and their alternatives, and

- the behavior of the market.

For example, to understand the generation system impact of renewable energy resources, it is important to understand not only how much renewable energy is required to meet the policy and therefore is coming into the grid, but what type of renewable resource will be available and that resource's operating characteristics

(capacity factor, energy generation profile).[10] States also want to understand the cost and other impacts of the energy efficiency and renewables driven by the clean energy policy or mandates.

These types of questions require methodologies and approaches that consider technology characteristics, economics, and market conditions. For example, estimating energy impacts from energy efficiency requires an understanding of the current penetration of a technology, applicability to new (or existing) homes, customer financial requirements and preferences, penetration patterns, and load shape impacts. Analysis of appliance standards or building codes requires understanding the technologies, but also the system impacts at the building level. In addition states must understand the potential impacts across the entire population of affected buildings. Again, more advanced techniques may be required, such as building simulation tools and market penetration models, but some basic non-modeling methods may apply. The range of approaches is described below.

Approaches

Assessing the potential impacts of energy efficiency or renewable energy programs requires "bottom up" economic and/or engineering-based estimation techniques—building up estimates of impacts based on a representation of the fundamentals of the technology, the economics, and market behavior. These bottom-up approaches involve estimating potential energy savings at a very detailed level and rolling these estimates up to the clean energy or statewide initiative level.

Analyses typically involve basic to sophisticated calculations or spreadsheet analysis, and the collection of data and information about the experiences or analyses of programs within and outside of the state. Depending upon the level of sophistication used in the analysis, the analysis may or may not consider explicitly local economics, transmission requirements, or generation system impacts. The most basic types of analyses (i.e., those that exclude those factors) may be useful only for developing short-term impact estimates, depending on the extent of the comparable historical experience.

Depending upon the level of detail desired and the amount of new analyses needed, estimating the

potential impacts can require an extensive amount of data and, for the more detailed analyses, may be costly.

At a minimum, the analysis will require some level of detail about the:

- *Individual measure savings or renewable energy savings* that can be rolled up into an aggregate estimate or state-wide strategy, and

- *Saturation of energy efficiency or renewable energy equipment* in the market so that the state can determine how much opportunity for new investment is feasible when compared against potential studies.

Individual Measure or Site-level Savings for Generation Estimates

To estimate the potential savings of clean energy measures, states can conduct simple analysis of estimated energy efficiency or renewable energy impacts based on an extrapolation of existing energy efficiency or renewable energy potential studies. These studies may be sector-specific (residential, commercial, industrial), or more aggregated at some geographic level (state or region). They may reflect technical potential, economic potential, or market potential, or all three. If only the first two estimates are provided, the analysis should consider what is achievable.[11]

States can also explore existing studies of similar programs in other states and adapt the results to their conditions. At the aggregate level this may mean scaling results to the state's load forecast, perhaps accounting for sectoral share differences if data are available at the sectoral level. For estimates of individual measure impacts or site-level impacts associated with clean energy measures, states can look to available retrospective studies that can be extrapolated into prospective savings based on an understanding of the state's sectoral and end-use mix. Table 2.2.5 lists resources on retrospective savings estimates and existing potential studies states can use to produce individual savings estimates.

These estimates can be summed across the populations in each sector, remembering to subtract the market penetration levels for the clean energy measures that are already installed (based on the saturation data, as

---

[10] *For information to help a state decide if biomass is a viable renewable energy option to consider and, if so, the most promising options to pursue, see EPA's State Bioenergy Primer* http://www.epa.gov/statelocalclimate/resources/bioenergy-primer.html

[11] *EPA has developed guidance on conducting an energy efficiency potential study. See Guide for Conducting an Energy Efficiency Potential Study, A Resource of the National Action Plan for Energy Efficiency, November 2007.* http://www.epa.gov/RDEE/documents/potential_guide.pdf

TABLE 2.2.5 RESOURCES FOR CLEAN ENERGY RETROSPECTIVE DATA AND POTENTIAL STUDIES

Resource	Description	Web Site
Market Assessment and Program Evaluation (MAPE) Clearinghouse	Database developed by *Consortium for Energy Efficiency* (CEE) that contains energy-efficiency program evaluation reports, potential studies, and related documents that are publicly available.	*http://www.cee1.org/eval/clearinghouse.php3*
Lawrence Berkeley National Laboratory (LBL)	Technical resource that tests and invents energy-efficient technologies and provides publicly available research reports and case studies on EE and RE.	*http://www.lbl.gov; http://eetd.lbl.gov/ea/ems/cases/*
Renewable Energy Policy Project (REPA)	Research papers, primarily on RE. Example reports are "Wind Energy For Electric Power" and "Powering the South: A Clean and Affordable Energy Plan for Southern United States," which includes EE and RE.	*http://www.repp.org/repp/*
American Council on Energy Efficient Economy (ACEEE)	Consumer resources on appliances, policy, potential study workshops, technical papers.	*http://www.aceee.org/*
Tellus Institute	High-level reports presenting scenarios on increased efficiency and renewable energy standards, reporting on their impact on the environment. Also provides additional links to the software models used by the Institute, including LEAP (Long-range Energy Planning).	*http://www.tellus.org/*
National Renewable Energy Laboratory (NREL)	Provides data on RE and EE technology, market, benefits, costs, and other energy information.	*http://www.nrel.gov/analysis/*
California Database of Energy Efficiency Resources (DEER)	Provides documented estimates of energy and peak demand savings values, costs, and effective useful life. In this California Energy Commission and California Public Utilities Commission sponsored database, data are easy to research and could be used as input into internally developed spreadsheets on appliances and other EE measures, which can be adjusted for the circumstances of different states.	*http://www.energy.ca.gov/deer/*
Regional Technical Forum (RTF) deemed savings database	Developed by the Northwest Planning Council staff, with input from other members of the regional technical forum, which includes utilities in the four-state region of Oregon, Washington, Idaho, and Montana. Both residential and commercial EE measures are included.	*http://www.nwcouncil.org/energy/rtf/supportingdata/default.htm*
Entergy Texas Deemed Savings	Entergy, an investor-owned utility (IOU), provides deemed energy savings for EE measures, much as the other IOUs in Texas do. It accounts for the weather zone of the participants. These data could be used as input into internally developed spreadsheet regarding appliances and other EE measures for a bottom-up method. The data may have to be adjusted for a different state.	*http://www.entergy-texas.com/content/Energy_Efficiency/documents/HelperApplication_HTR_Entergy_2006.xls*

described in greater detail below). When implementing this approach of adapting existing studies to evaluate renewable energy options, states should correct for the relative resource base available since states have different levels of renewable energy resources (e.g., wind, solar) available. The results should be adjusted to reflect any difference.

Saturation of Energy Efficiency or Renewable Energy Equipment

It is important to understand how much equipment is already in the market so that states can determine a feasible level of investment that a new clean energy program or policy could induce. The equipment saturation data are typically determined using one or more methods, including:

▪ *End-use Customer Saturation Surveys.* These surveys provide a relatively cost-effective method of estimating saturation levels for both standard and efficient equipment. These on-site, telephone or Internet surveys are conducted to gather information regarding the end-use equipment currently installed at a statistical sample of homes and businesses.

▪ *Site Visits.* Facility managers can provide high-quality estimates of equipment saturations. However, due to the tremendous amount of energy consumption represented by large nonresidential facilities, and the limited amount of program audit data available, it is often necessary to conduct primary data collection at a sample of sites that represent the sub-sectors in the population.

▪ *Survey of Retailers.* Retailers can provide important insight into the market share and saturation of a number of products, including programmable thermostats, water heaters, clothes washers, clothes dryers, and refrigerators.

▪ *Surveys of Builders and Code Officials, Builders, Architectural and Engineering Firms, and Other Trade Allies.* These data can be also be used to characterize the equipment saturations in the new construction and retrofit markets if samples are carefully selected and appropriate survey instruments developed. Interviews with contractors, dealers, distributors, and other trade allies provide a cost-effective research approach, as business activity tends to be concentrated among relatively few market actors. Trade ally interviews can also be leveraged to assess market share and estimates of market saturation for multiple sectors during a single interview.

Once equipment saturation is understood, states can compare it against potential studies to determine the feasible level of investment opportunity available.

Tools for Direct Savings or Generation Estimates

A number of modeling and analytics tools are available to help states estimate the potential direct energy impacts of clean energy measures. Table 2.2.6 provides examples of some simple analysis tools available when employing non-integrated modeling approaches to estimating energy savings from EE and RE initiatives. The tools shown in the table are organized by web-based, spreadsheet, and software tools. Some of these tools are designed to develop site-level savings estimates that can be aggregated up to the state.

For example, the site-level estimates from tools such as eQuest® (for EE measures) or PVWatts™ (for estimating solar system electricity production) are summed across expected participant populations to get statewide energy savings estimates. Other tools (e.g., DSMore™) are intended to provide program-level rather than site-level estimates of energy savings.

Depending upon the level of detail desired, the tools and methods described above have the ability to produce detailed information about the clean energy technology's patterns of operation. Building simulation models, for example, produce detailed hourly load patterns reflecting when an energy-efficient technology reduces demand for a given building, application, and climate zone. This information is needed to assess the detailed impact on the utility system, specifically what generation technology will be displaced or avoided over the long term. Load shapes for particular technologies can also be acquired from third parties if building simulations are not used.

Analysis of a renewables policy or program would examine the costs and operation of eligible renewable resources and their interaction with the existing (and planned future) generation system. This type of analysis is often more complex, and therefore may require a more sophisticated approach. A sophisticated capacity planning and system dispatch model, for example, would require information on the costs and performance of renewables, as well as energy efficiency options and their penetration potentials. Some of these models have the ability to model energy efficiency and renewable energy explicitly, reflecting potential EE load shape impacts and penetration patterns, and energy generation profiles for renewables. Others treat these non-dispatchable and intermittent resources in simpler ways.

Several sources are available to help predict the load profile of different kinds of renewable energy and energy efficiency projects as listed below.

▪ Performance data for renewable technologies are available from the National Renewable Energy Laboratory (NREL), as well as universities and other organizations that promote or conduct research on the applications of renewable energy. For example the Massachusetts Institute of Technology's Analysis Group for Regional Energy Alternatives and Laboratory For Energy and the Environment conducted a 2004 report, Assessment of Emissions Reductions from Photovoltaic Power Systems

TABLE 2.2.6 EXAMPLES OF AVAILABLE TOOLS FOR ESTIMATING DIRECT ENERGY IMPACTS

Tool Name	Level of Analysis	Description	Source
Internet Based Methods			
eCalc™	New /retrofit buildings Renewable energy sources (e.g., solar heating, solar PV, wind power)	Web-based calculator that enables users to design and evaluate a wide range of clean energy projects for energy savings and emissions reduction potential. In addition to buildings and renewable energy sources, eCalc calculates energy savings for municipal wastewater projects, traffic lights, and street lighting projects.	*http://ecalc.tamu.edu/*
ENERGY STAR® Savings Calculators	Energy efficiency measures	Series of tools that calculate energy savings and cost savings from ENERGY STAR-qualified equipment. Includes commercial and residential appliances, heating and cooling, lighting, office products, and other equipment.	*http://www.energystar. gov/purchasing*
ENERGY STAR Roofing Comparison Calculator	Buildings	Estimates energy and cost savings from installing an ENERGY STAR® labeled roof product in a home or building.	*http://www.roofcalc.com/ default.aspx*
ENERGY STAR Target Finder	New buildings	Helps planners, architects, and building owners set aggressive, realistic energy targets and rate a building design's estimated energy use. Use the tool to determine: ▪ Energy performance rating (1–100), ▪ Energy reduction percentage (from an average building), ▪ Source and site energy use intensity (kBTU/sf/yr), ▪ Source and site total annual energy use (kBTU), and ▪ Total annual energy cost. Can use to evaluate potential energy savings of new/planned buildings by building type for a clean energy policy (e.g., a building code policy) and apply savings across the population.	*http://www.energystar. gov/targetfinder*
ENERGY STAR Portfolio Manager	Existing buildings Portfolio of buildings	Online, interactive tool that benchmarks the performance of existing commercial buildings on a scale of 1-100 relative to similar buildings. Tracks energy and water consumption for building or portfolio of buildings and calculates energy consumption and average energy intensity. Can use to evaluate potential energy savings of existing buildings by building type for a clean energy policy (e.g., a building code policy) and apply savings across the population.	*https://www.energystar. gov/benchmark*
PVWatts™	Grid-connected PV systems	A solar technical analysis model available from NREL that produces an estimate of monthly and annual photovoltaic production (kWh) and cost savings. Users can select geographic location and use either default system parameters or specify parameters for their PV system. Data can be used to accumulate project specific savings toward renewable energy policy goals for solar-related technologies.	*http://rredc.nrel.gov/solar/ codes_algs/PVWATTS/ version1/*
Spreadsheet Based Methods			
WindPro	Wind turbines Wind farms	A Windows modular-based software suite for designing and planning single wind turbines and wind farms.	EMD International, WindPro: *http://www.emd. dk/WindPRO/Introduction/*

Tool Name	Level of Analysis	Description	Source
RETScreen® Clean Energy Project Analysis Software	Renewable energy and energy efficiency projects	Use to evaluate the energy production and savings, costs, emission reductions, financial viability, and risk for various types of clean energy technologies, including renewable energy, cogeneration, district energy, clean power, heating and cooling technologies, and energy efficiency measures.	http://www.retscreen.net/ang/home.php
DSMore™	DSM programs	Designed to evaluate the costs, benefits, and risks of DSM programs and services. Evaluates thousands of DSM scenarios over a range of weather and market price conditions. While requiring detailed input data, the model uses these data to produce detailed outputs, including energy savings impacts associated with the type of fuel that is being saved (gas or electricity), and provides for expansive scenario analyses.	Integral Analytics: http://www.integralanalytics.com/dsmore.php
Software Methods			
fChart and PV-fChart	Solar PV or solar thermal systems	fChart Software produces both fChart and PV-fChart for the design of solar thermal and photovoltaic systems, respectively. Both programs provide estimates of performance and economic evaluation of a specific design using design methods based on monthly data.	http://www.fchart.com/index.shtml
eQuest®	Buildings	Building simulation model for weather-dependent energy efficiency measures, Energy savings can be applied across the population.	http://www.doe2.com/equest/
ENERGY-10™	Buildings	Small commercial and residential building simulation models. Can conduct a whole-building analysis, evaluating the energy and cost savings that can be achieved by applying energy-efficient strategies such as daylighting, passive solar heating, and high-performance windows and lighting systems.	http://www.nrel.gov/buildings/energy10.html
DOE-2	Buildings	A building energy analysis computer program that predicts the hourly energy use and energy cost of a building given hourly weather information and a description of the building and its HVAC equipment and utility rate structure.	http://www.doe2.com/DOE2/index.html

(*http://web.mit.edu/agrea/docs/MIT-LFEE_2004-003a_ES.pdf*). Another useful source is the Connecticut Energy Conservation Management Board (*http://www.ctsavesenergy.org/ecmb/index.php*).

▪ The California Database for Energy Efficient Resources provides estimates of energy and peak demand savings values, measure costs, and effective useful life of efficiency measures (*http://www.energy.ca.gov/deer/*).

▪ Some states or regions have technology production profiles in their efficiency and renewable energy potential studies (e.g., NYSERDA's report, *Energy Efficiency and Renewable Energy*

Resource Development Potential in New York State, 2003, available at *http://www.nyserda.org/sep/EE&ERpotentialVolume1.pdf*).

▪ Load Impact Profile Data for energy efficiency measures may be available for purchase from various vendors, but typically is not publicly available in any comprehensive manner.

▪ Wind profiles can be obtained from a number of sources, including the Department of Energy's NEMS model (*http://www.eia.doe.gov/oiaf/aeo/overview/*), NREL (*www.nrel.gov*), the American Wind Energy Association (*www.awea.org*), and several research organizations that have published

information on wind resources in specific locations. All data will likely require some extrapolation or transposition for the intended use.

Considerations

When estimating the potential direct energy impacts, states should consider the cost-effectiveness of the measure or programs in the context of the avoided costs[12] of the utility system or region where they are implemented. To evaluate cost-effectiveness, states can conduct simple economic analyses such as project-level discounted cash flow analysis. Using cash flow analysis, the state develops estimates of the discounted cash flow of alternative options reflecting any incentives available under the program or policy, and simply compares those with avoided costs (obtained from the PUC or other entity, or estimated as discussed in Chapter 3) in the region. For financial incentive-based programs, measures that are less than the avoided cost (considering the incentive) could be expected to enter the mix. For renewable mandates, technologies ranging from least-to-most cost could be considered part of the potential compliance set up to the minimum amount of capacity required by the portfolio standard or goal.

It is important to remember, for this and more sophisticated methods, that there will be some degree of non-compliance for certain mandated programs. For example, building codes do not achieve 100 percent compliance and enforcement is not complete. Calculations should factor non-compliance into the equation.

There are limits to this methodology. For example, the revenue stream received by renewables will depend on when they are operative (especially in competitive markets). This method would miss the true distribution of costs that developers would face, and thus would provide only a rough estimate of the financial performance of these projects. It is important to note that more sophisticated methods require this same data for modeling the performance, economics, and penetration of these technologies.

STEP 3.3: Determine Assumptions and Review Available Data

Determining potential direct energy impacts attributable to clean energy programs and policies requires careful selection of assumptions based on state-specific demographic and climatic conditions. Several

assumptions should be considered when estimating the prospective energy savings of a clean energy initiative. These include:

- *Program period:* What year does the program start? End?

- *Program target:* What sector or consumer type is the focus of the program?

- *Anticipated compliance or penetration rate:* How many utilities will achieve the target or standard called for? How many consumers will invest in new equipment based on the initiative? How will this rate change over the time period?

- *Annual degradation factor:* how quickly will the performance of the measure installed degrade or become less efficient?

- *Transmission and distribution (T&D) loss:* Is there an increase or decrease in T&D losses that would require adjustment of the energy savings estimate?

- *Adjustment factor:* How should the estimate be adjusted to factor in any inaccuracies in the calculation process?

- *Non-program effects:* What portion of the savings is due to factors outside of the initiative?

- *Funding and administration:* What is the budget for the program and how will it be administered? What are the administrative costs? How much will this reduce the amount of money available to directly obtain energy savings?

- *Energy efficiency and renewable energy potential:* How do the savings projected compare to the potential available? Are they realistic and consistent with other relevant studies?

States can look to existing analyses to discover the assumptions others have made while analyzing similar programs. Multiple resources provide historical results and projected EE and RE energy savings, including those listed in Table 2.2.1. Other data sources include the U.S. ENERGY STAR Program,[13] the various utility online audit services, and manufacturers and national retailers. States can look to other state agencies (e.g., state energy and environmental offices) that may be working on similar studies and have data on clean energy estimates. Step 3.2 *Choose Method to Estimate*

---

[12] *For more information about avoided costs, see Chapter 3, Assessing the Electric System Benefits of Clean Energy.*

[13] *http://www.energystar.gov/*

Potential Direct Energy Impacts contains examples of publicly available EE and RE data resources.

Additionally, states can assess available potential studies that support the clean energy policy decision. For example, a potential study conducted for another state may contain valuable information on the energy savings associated with different clean energy programs, and deemed savings databases from other states will include energy savings for specific EE measures.[14] Public service commissions' Web sites usually post utility DSM filings and Integrated Resource Plans, which contain details on EE and RE plans with estimated energy savings.

In using data from other states or regions, it is important to choose states that have similar climate and customer characteristics. Even so, the assumptions about operating characteristics of different clean energy technologies typically need to be adjusted for the specifics of the state that is the focus of the study. For example, for energy efficiency measures, adjustments for differences in weather are typically made, along with adjustments for state-specific population characteristics.

STEP 3.4: Apply Model or Approach

In this step, states use the assumptions they develop and apply the selected model or approach to the clean energy initiative to estimate clean energy savings.

Examples of simple, bottom-up analyses of policy options are presented below for appliance efficiency standards, renewable portfolio standards, and lead by example initiatives.

Air Conditioner Efficiency Standards

A state that is considering a new efficiency standard for air conditioning could estimate energy savings based on a variety of already-available data. The assessment could use measure-specific energy savings from a deemed savings database from another state (e.g., the California Database of Energy Efficiency Resources), and adjust the measure-specific savings to account for the weather zones present in the state, especially for weather-specific measures such as high-SEER air conditioning. These adjustments might require the use of building simulation models (e.g., eQuest; see Table 2.2.6) to get reasonably accurate estimates of energy savings at the site level. These site-level savings would ideally be

generated for each housing type, air conditioning rating level above federal standards, and weather zone. This can create a large matrix of possible combinations.

Determining baseline market penetration of the higher efficiency technology without conducting surveys of HVAC dealers can be accomplished by reviewing studies of market penetration rates from another state (or states). These studies would need to be from states that had not already adopted a higher efficiency technology standard, and the results of the studies would need to be adjusted for demographic differences between the states.

Combined with some thoughtful analysis, these data can help define the potential energy savings for the proposed air conditioning measures without incurring the time and expense of collecting all new data. Making choices about which data to use and how to make adjustments to those data involves inherent trade-offs between the expected accuracy and the level of effort expended. For example, using other states' existing studies and applying basic adjustments to account for different conditions would require less effort than collecting region-specific data and developing savings models for the local environment, but also would be expected to yield a lesser degree of accuracy than would the latter approach. Some analysis of the uncertainty surrounding each key variable is recommended in order to understand the relative accuracy of the estimates obtained through these methods.

Renewable Portfolio Standard

In a similar manner, an estimate of the potential energy savings associated with a renewable portfolio standard (RPS) can use data from surrounding states and/or those that have adopted similar rules regarding the implementation of their RPS. For example, a state might look at adoption rates for roof-mounted solar photovoltaics in other states that have similar net metering rules for solar systems and have established incentives for installation that reward end-users and developers in a similar manner financially.[15]

Assumptions regarding the energy production of the system, financial discount rate, and other factors must be reviewed and projected in order to estimate

---

[14] *Deemed savings are validated estimates of energy savings associated with specific energy efficiency measures that may be used in place of project-specific measurement and verification.*

[15] *If the comparison state's financial incentives took the form of an upfront rebate, and a future revenue stream based on RECs is assumed for the state being analyzed, then a discounted cash flow analysis would be required to analyze the net present value (NPV) of each approach to the project owner and solar developer in order to compare the costs of the two approaches fairly.*

attractive rates of return that will stimulate the market at the project level.

To extrapolate the project level analyses to the population, factors including demographic data, the current status of the solar industry in the state, and the current economic climate are required to estimate a range of savings that may be achieved through the policy over a period of several years.

Lead by Example

To determine the energy savings from a *lead by example* policy of reducing energy consumption in all state-owned buildings 20 percent by 2020, a few basic steps are required. The first is to gather the baseline data for state-owned facilities, specifically their energy consumption data for at least the past several years, along with the square footage associated with each facility. These data may take some time and effort to gather, as they do not typically reside in one file or with one person.

Having the baseline data allows for summation of the target kWh and therm reductions across all facilities. If the policy will reduce energy consumption in existing buildings alone, calculating the savings number is as simple as determining whether each facility will achieve 20 percent savings, or the portfolio as a whole will achieve a 20 percent reduction in annual consumption. Either way, it is a straightforward exercise to take 20 percent of the kWh and therms usage summed for the base year. If the policy is to include new construction as well, a determination of what the baseline construction would have been for new state facilities in the absence of the initiative, and an assessment of the energy consumption associated with facilities built to that evolving standard multiplied by the square footage of planned additions, are needed.

To build a true bottom-up analysis of savings, though, it is necessary to find where the 20 percent savings are likely to come from. Individual building audits will provide the best data on where to achieve savings, and can be summed by end-use, facility, and organization up to the state level. But this process is relatively expensive and time consuming, and a first-level screening might involve benchmarking the facilities with national averages and best-practice energy consumption per square foot.[16]

After initial screening, walk-through audits can be used to confirm where to target the most cost-effective initial investments. Most cost-effective energy efforts start with lighting retrofits, as they are a proven energy savings that can be easily achieved. Heating, ventilating, and air conditioning improvements or control system upgrades will require a more detailed audit, often take longer to complete, and require less modular investments. Engineering algorithms or simulation models are used to estimate the savings from HVAC and other EE measures, and to estimate interactive effects that may decrease the combined savings of individual measures.

The level of detail desired may depend on the purpose of the estimates. If, for example, agency budgets were dependent upon their energy savings, a more detailed analysis would provide better information about specific technology performance and payback than a screening-type of analysis. Regardless of the level of detail, the state would sum up the measure and building savings estimates across all facilities to assure that the 20 percent by 2020 statewide target can be met within the budgets allocated.[17]

STEP 3.5: Evaluate Output

Once potential energy savings or generation impacts are estimated, it is important to evaluate these results to ensure that the numbers are reasonable and meet the state's policy goals. If the state determines that the results are not realistic, it may need to review its assumptions and reapply the approach or model in an iterative fashion to achieve reasonable energy savings estimates. The resulting energy savings estimates can be compared to a potential study, if available, to ensure that the policy analysis does not overestimate the possible savings.

2.2.4 STEP 4.0: CREATE AN ALTERNATIVE POLICY FORECAST

Once the direct energy impacts of clean energy are estimated, an alternative policy forecast must be created that adjusts the BAU energy forecast developed under Step 1 to reflect the clean energy policy or program. In the case of efficiency, the energy savings estimates would be subtracted from the BAU forecast to create a

---

16 *When benchmarking facilities in this way, it is important to use benchmarks specific to that building type. For example, a hospital has a very different energy profile than does an office building, so only hospital-specific benchmarks would be useful for benchmarking a hospital. See ENERGY STAR's Portfolio Manager at* http://www.energystar.gov/benchmark.

17 *Of course, other financing mechanisms for energy efficiency are available, including bidding out the services to Energy Service Companies (ESCOs). This chapter does not explore financing mechanisms, but focuses on energy savings calculation methods and mentions the budget implications only as a consideration for policy makers.*

new forecast.[18] For clean energy supply alternatives, the policy forecast can be created with the sophisticated supply forecasting models used to develop the original BAU forecast (see Table 2.2.3). The assumptions in the model would need to be adjusted to reflect the change in renewable energy supply expected from the clean energy initiative.

The impact estimates – and many of the same sophisticated demand and supply models – can also be used to assess impacts on the electric power system and project what generation is likely to be displaced that otherwise would have been in operation. This is discussed in more detail in Chapter 3, Assessing the Electric System Benefits of Clean Energy. In addition, the estimates can also be used to determine environmental and economic benefits as described in Chapters 4 and 5 respectively.

ISSUES AND CONSIDERATIONS

- Incentives that are associated with the clean energy policy can alter the energy savings estimates (e.g., a renewable tax credit could increase renewable energy production beyond RPS levels). If historical trends do not reflect these incentives, or non-economic based methods are used, states should attempt to reflect the potential response to these incentives.

- Technologies change over time and can alter energy savings estimates. This can alter the BAU forecast and the potential for energy savings. BAU forecasts and energy savings projections should be reevaluated periodically (every one to two years). This is particularly important under conditions of rapid change.

- Measurement and verification studies, which estimate the actual energy savings of a clean energy measure, can be used retrospectively to ensure that an implemented clean energy program's performance was reliably estimated and is meeting the policy goals set out for the program.

- As with all analyses, transparency increases credibility. Be sure to document all sources and assumptions.

---

[18] *Alternatively, two forecasts may be produced, with and without the clean energy, and the difference would represent clean energy impacts. This methodology would be more likely when using bottom-up economic-engineering approaches.*

2.3 CASE STUDIES

2.3.1 TEXAS BUILDING CODE

Impacts Assessed:

- Electricity Savings
- NO_x Reductions

Clean Energy Program Description

The Texas Emissions Reduction Plan (TERP), initiated by the Texas Legislature (Senate Bill 5) in 2001, establishes voluntary financial incentive programs and other assistance programs to improve air quality [i.e., ozone formed from nitrogen oxides (NO_x) and volatile organic compounds (VOCs)] in the state. One component of TERP recognizes the importance of energy efficiency and renewable energy measures in contributing to a comprehensive approach for meeting federal air quality standards. Consequently, the legislation requires the Energy Systems Laboratory (ESL) at the Texas Engineering Experiment Station of the Texas A&M University System to submit an annual report to the Texas Commission on Environmental Quality estimating the historical and potential future energy savings from energy building code adoption and, when applicable, from more stringent local codes or above-code performance ratings. The report also includes estimates of the potential NO_x reductions resulting from these energy savings. ESL has conducted this annual analysis since 2002 and submits it in a report entitled "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan." ESL also provides assistance to building owners on measurement and verification activities.

Method(s) Used

ESL determines the energy savings and resulting NO_x emissions for new residential single- and multi-family construction and for commercial office buildings in Texas counties that have not attained federal air quality standards. Its analysis is based on the energy efficiency provisions of the IRC for single-family residences and the IECC for all other residential and commercial buildings. A brief summary of the approach for estimating energy savings for both types of buildings is provided below.

Residential Buildings. First, new construction activity by county is determined. Next, annual and peak day energy savings (in kWh) attributable to the building code are modeled using a DOE-2 simulation that ESL

developed for the TERP. These estimates are then applied to National Association of Home Builders survey data to determine the appropriate number of housing types.

Commercial Buildings. The process to estimate energy savings begins with estimating the number of buildings and relative energy savings. The Dodge MarkeTrack database provides construction start data and is used to gather the square footage of new commercial construction in Texas. These data are merged with energy savings calculations published by the Pacific Northwest National Laboratory (PNNL), along with the 1995 and 2003 Commercial Building Energy Consumption database. The PNNL energy savings, which represent buildings built to ASHRAE Standard 90.1-1989 versus Standard 90.1-1999, are applied to the published square feet of new construction.

After residential and commercial building savings are estimated, these savings are projected to 2013 by incorporating a variety of adjustment factors. These factors include:

- *Annual degradation factor*: This factor was used to account for an assumed decrease in the performance of the measures installed as the equipment wears down and degrades. An annual degradation factor of 5 percent was used for all the programs. This value was taken from a study by Kats et al. (1996).

- *T&D loss*: This factor adjusts the reported savings to account for the loss in energy resulting from the transmission and distribution of the power from the electricity producers to the electricity consumers. For this calculation, the energy savings reported at the consumer level were increased by 7 percent to give credit for the actual power produced that is lost in the transmission and distribution system on its way to the customer. In the case of electricity generated by wind, it was assumed there was no net increase or decrease in T&D losses, since wind energy is displacing power produced by conventional power plants.

- *Initial discount factor:* This factor was used to discount the reported savings for any inaccuracies in the assumptions and methods employed in the calculation procedures. For single- and multi-family programs, the discount factor was assumed to be 20 percent.

- *Annual growth factor* for single-family (3.25 percent), multi-family (1.54 percent), and for commercial (3.25 percent) construction, derived from recent U.S. Census data for Texas.

The state assumed that the same amount of electricity savings from the code-compliant construction would be achieved for each year after 2007 through 2013.

Results

- The ESL 2008 annual report on the energy efficiency and renewable energy impacts of the TERP, submitted to the Texas Commission on Environmental Quality in December 2008, describes prospective energy savings resulting from implementing the International Residential Code (IRC) and the International Energy Conservation Code (IECC) in residential and commercial buildings, respectively, through 2020. According to the report, the cumulative annual energy savings from code-compliant residential and commercial construction were estimated to be:

- 1,440,885 megawatt hours (MWh) of electricity each year from 2001 through 2007, and

- approximately 2.9 million MWh by 2013, accounting for 10 percent of the cumulative total electricity savings under all energy efficiency and renewable energy programs implemented under the TERP between 2008 and 2013 (Texas A&M Energy Systems Laboratory, 2007).

ESL divided the actual and projected energy savings into the different Power Control Authorities and, using US EPA's eGRID emission factors, calculated the cumulative annual NO_x emission reduction values as follows:

- 1,014 tons-NO_x/year in 2007, and

- 2,047 tons/year by 2013.

For More Information

- *Energy Efficiency/Renewable Energy Impact in The Texas Emissions Reduction Plan (TERP).* Volume I—Summary Report: Annual Report to the Texas Commission on Environmental Quality. January 2007–December 2007. August 2008, Revised December 2008. Energy Systems Laboratory, Texas Engineering Experiment Station, Texas A&M University System. *http://esl.eslwin.tamu.edu/docs/documents/tceq/ESL-TR-08-12-01%20tceq-report-2007-Vol-I-FINAL.pdf*

- *Energy Efficiency/Renewable Energy Impact In The Texas Emissions Reduction Plan (TERP)*. Preliminary Report: Integrated NO$_x$ Emissions Savings From EE/RE Programs Statewide: Annual Report to the Texas Commission on Environmental Quality January 2007–December 2007. August 2008. *http://esl.eslwin.tamu.edu/docs/documents/ESL-TR-08-08-01.pdf*

- *Development of a Web-based Emissions Reduction Calculator for Code-Compliant Commercial Construction*. Texas A&M Energy Systems Laboratory. 2005. *http://txspace.tamu.edu/bitstream/handle/1969.1/5128/ESL-IC-05-10-34.pdf?sequence=1*.

- *Development of a Web-based Emissions Reduction Calculator for Code-Compliant Single-Family and Multi-Family Construction*. Texas A&M Energy Systems Laboratory. 2005. *http://txspace.tamu.edu/bitstream/handle/1969.1/5127/ESL-IC-05-10-33.pdf?sequence=1*.

2.3.2 VERMONT - ENERGY AND ENERGY SAVINGS FORECASTING

Activities:

- Energy forecasting

- Energy savings forecasting

Background

The Vermont Department of Public Service (DPS) conducts energy demand and energy efficiency program savings forecasting as part of its long-term state energy policy and planning process. This process includes:

- The Comprehensive Energy Plan (CEP, required under statute to be conducted every five years),

- The 20-Year Electric Plan (also required every five years), and

- A variety of other state planning initiatives (Vermont DPS, 2008).

The state uses the CEP as a tool to help manage the transition from traditional energy fossil fuel to cleaner energy supplies in order to benefit Vermont's economic and environmental future. It provides a means for them to show how energy demand and energy efficiency program forecasts fit into the bigger planning picture.

TABLE 2.3.1 VERMONT PROJECTED ENERGY DEMAND 2008-2010: WITH AND WITHOUT NEW DSM

Year	Without New DSM (GWh)	With New DSM (GWh)	Energy Savings (GWh)
2008	6,356	6,356	0
2009	6,324	6,256	68
2010	6,436	6,243	193
2011	6,552	6,235	317
2012	6,685	6,242	443
2013	6,821	6,254	567
2014	6,925	6,253	672
2015	6,941	6,181	760
2016	6,977	6,131	846
2017	7,042	6,110	932
2018	7,123	6,107	1,016
2019	7,205	6,105	1,100
2020	7,293	6,113	1,180
2021	7,381	6,125	1,256
2022	7,370	6,046	1,324
2023	7,440	6,059	1,381
2024	7,516	6,089	1,427
2025	7,583	6,121	1,462
2026	7,634	6,146	1,488
2027	7,681	6,171	1,510
2028	7,648	6,120	1,528
Total	148,933	129,463	19,470
AAGR	0.93%	- 0.19%	

AAGR=Average Annual Rate of Growth

Method(s) Used

For the 2008 study, the Vermont DPS began its analysis by examining historical energy consumption in Vermont across all sectors by selected fuel categories between 1960 and 2005. It also uses the historical data to compare energy demand in Vermont with demand in New England and the United States from 1990 through 2004.

The process to forecast electricity and peak demand in the state required several steps:

1. *Determine fuel price projections and avoided costs* (i.e., the marginal energy supply costs that will be avoided through savings in electricity, natural gas,

and other fuels from a range of DSM programs.) Consultants used DOE fuel price projections, customized them to Vermont conditions, and determined avoided costs using a screening tool that contains load shapes for each measure and type of program.[19]

2. *Estimate the achievable, cost-effective potential for electric energy and peak demand savings.* The level of efficiency potential in Vermont by DSM programs was determined using the avoided cost estimates from the first step along with various cost-effectiveness tests (GDS, 2006).

3. *Develop a 20-year forecast of electric energy use.* DPS hired consultants to develop a baseline projection of energy demand given current trends and use patterns and a forecast of expected demand, assuming implementation of the new DSM measures, built up from estimates of energy use by appliance type and end-use category by sector (e.g., the number of refrigerators in the residential sector) and the savings potential for each. Using regression and trend analysis, Vermont ran one 20-year baseline forecast without new (projected) DSM programs, and one case with assumed levels of new DSM program activity. [20]

4. *Develop a peak demand forecast.* DPS also looked at DSM savings using an econometric model base that included historical DSM investments as an independent variable. This method took a more conservative approach than the regression analysis used to project electric energy demand, in that it gives equal weight to the past 20 years of DSM program impacts and so may understate the credit deserved by energy efficiency measures going forward.

Results

These historical data and the analysis show demand for energy growing, driven by population growth, economic development, larger homes, and increases in vehicular travel. While overall energy demand appeared to show more rapid growth in Vermont than for the United States and New England, the reverse is true

within the electricity sector, which has been the object of intensive, formal energy efficiency program investments through Vermont's Energy Efficiency Utility. In addition, Vermont faces a large supply gap if major power contracts are not replaced, and the state projects higher costs for new resources to replace them. In light of this, Vermont committed itself to pursuing very aggressive energy efficiency measures.

Based on the energy efficiency potential results determined above, the DPS recommended DSM policies and a budget for programs. The Vermont Public Service Board approved the budgets and the Efficiency Utility established the specific programs (subject to Public Service Board review).

The electricity forecasts projected that without new DSM measures, electricity demand would grow an average of 0.93 percent on an average annual basis between 2008 and 2028. When new DSM measures are implemented, the DPS anticipates that energy demand will remain fairly flat, with a decline of 0.19 percent on an average annual basis.

The Vermont DPS is currently developing a comprehensive modeling approach using system dynamics (possibly relying on its older Energy 2020 model) to forecast energy savings from its DSM programs that would, ideally, better integrate the steps of its existing approach.

For More Information

- *Vermont Electric Energy Efficiency Potential Study, Final Report.* GDS Associates, Inc. May 10, 2006. Prepared for the Vermont Department of Public Service. *http://www.state.vt.us/psb/document/ElectricInitiatives/FinalReport-05-10-2006.doc*.

- *Vermont Comprehensive Energy Plan 2009 and Update to the 2005 Twenty-Year Electric Plan, Public Review Draft.* Vermont Department of Public Service. May 2008. *http://publicservice.vermont.gov/planning/CEP%20%20WEB%20DRAFT%20FINAL%206-4-08.pdf*.

- *Vermont's Energy Forecasting Efforts.* Vermont Department of Public Service. June 19, 2008. *http://www.epa.gov/statelocalclimate/documents/pdf/presentations_vt.pdf*.

---

[19] *The fuel cost and avoided cost assumptions were extensively reviewed by the Avoided Energy Supply Component Study Group, composed of New England utilities and PUCs.*

[20] *The regression equation includes variables for personal income, price, and trends to predict energy sales. The "with DSM" forecast was developed by subtracting the DSM savings projections from the base case "without DSM" forecast.*

Information Resources	URL Address
California Energy Commission (CEC). 2005. Energy Demand Forecast Methods Report. Companion Report to the California Energy Demand 2006-2016 Staff Energy Demand Forecast Report.	*http://www.energy.ca.gov/2005publications/ CEC-400-2005-036/CEC-400-2005-036.PDF*
CEC. 2007. California Energy Demand 2008-2018, Staff Revised Forecast	*http://www.energy.ca.gov/2007publications/ CEC-200-2007-015/CEC-200-2007-015-SF2.PDF*
Energy Information Administration (EIA). Commercial Buildings Energy Consumption Survey.	*http://www.eia.doe.gov/emeu/cbecs/*
EIA. Manufacturing Energy Consumption Survey.	*http://www.eia.doe.gov/emeu/mecs/*
EIA. Residential Energy Consumption Survey.	*http://www.eia.doe.gov/emeu/recs/*
Elliott, R. Neal and Anna Monis Shipley. 2005. Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets: Updated and Expanded Analysis. American Council for an Energy-Efficient Economy. April.	*http://www.aceee.org/pubs/e052full.pdf*
Elliot, R. Neal and Maggie Eldridge. 2007. Role of Energy Efficiency and Onsite Renewables in Meeting Energy and Environmental Needs in the Dallas/Fort Worth and Houston/ Galveston Metro Areas. American Council for an Energy-Efficient Economy. September.	*http://aceee.org/pubs/e078.pdf*
Massachusetts. 2001. Energy Efficiency Activities 1999, A Report by the Division of Energy Resources.	*http://www.mass.gov/Eoca/docs/doer/pub_ info/ee99-long.pdf*
Myers, Stephen, James McMahon, and Michael McNeil. 2005. Realized and Prospective Impacts of U.S. Energy Efficiency Standards for Residential Appliances: 2004 Update. Lawrence Berkeley National Laboratory, LBNL-56417. May.	*http://repositories.cdlib.org/lbnl/LBNL-56417/*
New Jersey. Market Analysis and Baseline Studies.	*http://www.njcleanenergy.com/main/public- reports-and-library/market-analysis-protocols/ market-analysis-baseline-studies/renewable*
Navigant Consulting Inc., Sustainable Energy Advantage LLC, and Boreal Renewable Energy Development. 2004. New Jersey Renewable Energy Market Assessment Final Report, August 2004, to Rutgers University Center for Energy, Economic and Environmental Policy.	*http://policy.rutgers.edu/ceeep/ publications/2004/remareport.pdf*
National Renewable Energy Laboratory (NREL). Energy Analysis – Slide Library.	*http://www.nrel.gov/analysis/slide_library.html*
NREL. Wind Research – Baseline Cost of Energy.	*http://www.nrel.gov/wind/coe.html*
New York State Energy Research and Development Authprity (NYSERDA). 2005. Executive Order No. 111 "Green and Clean" State Buildings and Vehicles. New York State Energy Research and Development Authority.	*http://www.nyserda.org/programs/pdfs/ execorder111finalreport11-05.pdf*
Summit Blue Consulting. 2008. Assessment of the New Jersey Renewable Energy Market, Volume I and II. Prepared for the New Jersey Board of Public Utilities. March.	*http://www.njcleanenergy.com/main/public- reports-and-library/market-analysis-protocols/ market-analysis-baseline-studies/renewable*
Texas A&M Energy Systems Laboratory (ESL). 2005. Development of a Web-based Emissions Reduction Calculator for Code-Compliant Commercial Construction.	*http://txspace.tamu.edu/bitstream/ handle/1969.1/5128/ESL-IC-05-10-34. pdf?sequence=1*
Texas A&M ESL. 2005. Development of a Web-based Emissions Reduction Calculator for Code-Compliant Single-Family and Multi-Family Construction.	*http://txspace.tamu.edu/bitstream/ handle/1969.1/5127/ESL-IC-05-10-33. pdf?sequence=1*
U.S. Environmental Protection Agency (EPA). ENERGY STAR.	*http://www.energystar.gov/*

Information Resources	URL Address
U.S. EPA. 2006. Clean Energy-Environment Guide to Action: Policies, Best Practices, and Action Steps for States. April.	*http://www.epa.gov/statelocalclimate/ resources/action-guide.html*
Vermont Department of Public Service. 2008a. Vermont's Energy Forecasting Efforts. June 19.	*http://www.epa.gov/statelocalclimate/ documents/pdf/presentations_vt.pdf*
Vermont Department of Public Service. 2008b. Personal communications with Riley Allen, Director of Planning, and Dave Lamont, Planning Engineer. 7/25/2008.	N/A

References	URL Address
GDS Associates, Inc. 2006. Vermont Electric Energy Efficiency Potential Study, Final Report. Prepared for the Vermont Department of Public Service. May 10.	*http://www.state.vt.us/psb/document/ ElectricInitiatives/FinalReport-05-10-2006.doc*
Kats, G.H., Arthur H. Rosenfeld, and Scott A. McGaraghan. 1996. Energy Efficiency as a Commodity: The Emergence of a Secondary Market for Efficiency Savings in Commercial Buildings. European Council for an Energy Efficient Economy.	*http://www.eceee.org/conference_ proceedings/eceee/1997/Panel_2/p2_26/ Paper/*
New Jersey. 2008. New Jersey Draft Energy Master Plan. April.	*http://www.state.nj.us/emp/home/docs/pdf/ draftemp.pdf* (draft plan) *http://www.state. nj.us/emp/* (all related reports)
NYSERDA. 2005. New York Energy $MART℠ Program, Evaluation and Status Report for the Year Ending December 2004. New York Public Service Commission and New York State Energy Research and Development Authority. May.	*http://www.nyserda.org/Energy_Information/ SBC/sbcmay05summary.pdf*
NYSERDA. 2008. New York Energy $MART℠ Program, Evaluation and Status Report for the Year Ending December 2007. New York Public Service Commission and New York State Energy Research and Development Authority. March.	*http://www.nyserda.org/pdfs/Combined%20 Report.pdf*
Texas A&M Energy Systems Laboratory (ESL). 2007. Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP). Volume II- Technical Report.	*http://txspace.tamu.edu/bitstream/ handle/1969.1/2077/ESL-TR-04-12-04. pdf?sequence=1*
Vermont Department of Public Service. 2008. Vermont Comprehensive Energy Plan 2009 and Update to the 2005 Twenty-Year Electric Plan, Public Review Draft. May.	*http://www.publicservice.vt.gov/planning/ CEP%20%20WEB%20DRAFT%20FINAL%206-4- 08.pdf*
Wisconsin Office of Energy Independence. 2007. Wisconsin Energy Statistics.	*http://energyindependence.wi.gov/docview. asp?docid=11632&locid=160*