Executive Summary

On June 25, 2013, President Obama announced a Climate Action Plan to (1) reduce US greenhouse gas (GHG) emissions; (2) adapt to the impacts of global warming; and (3) participate in international efforts to address global warming. The Climate Action Plan commits to reducing US GHG emissions to 17 percent below 2005 levels by 2020. Reducing carbon dioxide (CO_2) emissions from new and existing power plants is key to achieving that commitment, and a Presidential Memorandum released with the Climate Action Plan directed the US Environmental Protection Agency (EPA) to do so.

The EPA proposed CO_2 emissions standards for existing power plants on June 2, 2014 under Section 111(d) of the Clean Air Act. The final rule is expected in the summer of 2015. States will be expected to develop implementation plans consistent with the federal rule as early as June 2016. Consistent with the Clean Air Act Section 111, the proposed standards reflect the degree of emissions limitation achievable through the "best system of emission reduction" (BSER) that the EPA determined has been adequately demonstrated for fossil fuel-fired electric generating units (EGUs).

The EPA proposed emissions rate standards, or targets, for each state based on a BSER determination comprised of four *building blocks:* onsite heat rate improvements, redispatch to natural gas, renewable and nuclear energy, and energy efficiency. It is important to note, however, that states will not be limited in selecting compliance options to reduce emissions only from these building blocks. Rather, a state can choose any combination of measures in the building blocks, as well as other options that reduce CO_2 emissions, to achieve compliance with the emissions rate standards.

This report begins with 25 detailed chapters, each of which explores various approaches to GHG reduction in the electric sector. The *Menu of Options* looks first at proven *technologies* for reducing emissions, and then at various *policies* that have been demonstrated to promote or facilitate emissions reductions.

Each chapter starts with a profile, that is, a short description of the pros and cons of the approach. Next, a description of the regulatory backdrop, policy underpinnings, implementation experience, and GHG reduction potential associated with the approach are discussed. Each chapter then looks at co-benefits of the approach, including benefits to society and the utility system. Costs and cost-effectiveness are also explored. Finally, in Chapter 26, the *Menu of Options* more briefly explores a variety of emerging technologies and other important policies that regulators may wish to consider as they formulate plans to reduce power sector GHG emissions.

An overview of the 26 chapters is presented below.

Chapter 1 — Optimize Power Plant Operations

Boiler optimization and improved thermal efficiency are standard procedures that have been used for many decades. The recent development and maturity of artificial intelligence and neural networks to automatically adjust key variables and parameters de-emphasize the role of human intervention and help to ensure optimal boiler performance. Chapter 1 explores techniques to permit a plant to improve thermal efficiencies by up to four to seven percent, reducing coal combustion and GHG emissions by an equivalent quantity.

Chapter 2 — Implement Combined Heat and Power in the Electric Sector

One strategy for reducing CO_2 emissions from electric generating units is to capture their waste heat as a secondary output to serve other purposes, typically central heating and cooling or industrial processes in neighboring facilities. Combined heat and power, also known as CHP or cogeneration, is the term used to describe this variety of technology configurations that sequentially generates both electric and useful thermal output from a single fuel source. CHP provides a cost-effective, commercially available solution for near-term reductions in GHG emissions, with large technical potential distributed across the country. CHP results in direct energy savings to the user and offers a host of wider societal benefits, including reductions in air pollution, enhanced grid reliability, low-cost capacity additions, and improved resiliency of critical infrastructure. Chapter 2 focuses on CHP at central station EGUs as a means of reducing the carbon emissions of the power sector. This chapter also discusses the different types of CHP, how the Clean Power Plan would affect existing CHP and new opportunities, the variety of technologies that CHP can be based on, and examples of CHP projects.

Chapter 3 — Implement Combined Heat and Power in Other Sectors

This chapter discusses how CHP technologies in the commercial, institutional, and manufacturing sectors can reduce CO_2 emissions across the economy through system-wide gains in energy efficiency that improve economic competitiveness. Although CHP can take the form of large capacity power producers that sell bulk electricity to the grid, it can also be installed at facilities with onsite demand for both heating (or cooling) and electricity, like manufacturing facilities, universities, hospitals, and multifamily residential complexes, among others. While CHP is a technologically mature, cost-effective, and near-term strategy for environmental compliance, grid-tied CHP facilities can be complex, site-specific installations that carry significant technical and administrative burdens. Chapter 3 addresses a number of regulatory drivers currently affecting CHP, namely issues in utility and/or air pollution regulation, national and state CHP capacity targets, and grid reliability and resilience. This chapter also provides examples of CHP units that are designed primarily to meet onsite or nearby energy needs, rather than to supply electricity to the grid.

Chapter 4 — Improve Coal Quality

Power plant boilers are designed to accommodate a wide range of types of coal. However, within this range, variations in coal properties can affect performance and efficiency. A boiler designed to burn a high rank bituminous coal is going to perform quite differently if lower rank sub-bituminous coal is introduced, and properties such as high ash or sulfur content can impair not only the thermal performance of the boiler, but also associated systems, including duct work, steam temperature control, bottom and fly ash removal, pulverizers, burners, and combustion controls.

To maintain coal quality within specified ranges and meet boiler performance objectives, coals with different properties can be blended, either by the coal producer or at a power plant. Another option for meeting coal quality specifications is through "beneficiation," the industry's term for any of several processes and treatments that improve coal quality and have the potential to provide economic, energy, and environmental benefits for some units, depending on unit-specific design. Even small reductions in coal consumption on the order of one to two percent, for the same generating output, improve the profit margin of the power plant, extend the life of pollution controls, reduce the quantity of water and solid waste discharged, and reduce GHG, criteria pollutant, and mercury emissions. This chapter discusses different coal types and beneficiation options, examples of different types of beneficiation in practice, and the resulting GHG and environmental impacts of such actions.

Chapter 5 — Optimize Grid Operations

Electricity networks are changing today in ways that fundamentally challenge traditional grid reliability and planning tools. There is a long and growing list of system capabilities that can improve grid reliability, increase efficiency, reduce cost, and enhance operating performance. Each of these opportunities also typically reduces CO_2 emissions as a result of less – or lower-emitting – generation being needed. This is true at both the level of the transmission grid and the distribution system.

"Optimizing grid operations" refers to activities to improve the performance and efficiency of electricity transmission and distribution systems by grid operators. Performance improvements include better and lower-cost levels of grid reliability, more efficient delivery of electricity, reduced system losses, and increased capacity utilization for more efficient use of assets. The list of emerging strategies discussed in this chapter includes innovative applications of conservation voltage reduction, power factor optimization, phase balancing, the strategic use of electrical and thermal storage capabilities, and focused use of demand response capabilities. This chapter provides a brief overview of these strategies, the regulations that affect their implementation, and examples from around the United States.

Chapter 6 — Increase Generation from Low-Emissions Resources

More than two-thirds of the electricity generated in the United States is produced from fossil-fueled generators that emit substantial amounts of CO_2 and other GHGs, as well as many criteria and hazardous air pollutants. However, nearly all of the other technologies used to generate electricity produce far fewer emissions than fossil fuel technologies, or produce no emissions at all, including mature technologies like hydroelectric and nuclear power technologies, and resources like wind and solar. The potential for this wide range of zero- and low-emissions technologies is extremely large.

The GHG reduction benefits of zero-emissions generating resources are obvious and substantial, but will vary in the short-term depending on which higher-emitting resources are displaced (i.e., dispatched less often) owing to the availability of a zero-emissions alternative. The principal challenge associated with increased generation from zero- and low-emissions resources, aside from cost considerations, is likely to be that of integrating inflexible or non-dispatchable resources into the grid and balancing generation with demand on a real-time basis. This chapter analyzes the state of low-emissions resources in the United States and the policies that affect their deployment, and provides an overview of state implementation of these resources.

Chapter 7 — Pursue Carbon Capture and Utilization or Sequestration

Carbon capture and utilization and/or storage refers to a two-pronged approach to reduce CO_2 emissions from fossil fuel-fired EGUs and other CO_2-emitting facilities. At EGUs, CO_2 can be collected before or after combustion of fuel using various approaches. Following capture, the CO_2 can be compressed and transported to an injection site for underground storage, or used for productive purposes.

Carbon capture offers the potential to prevent the emissions of millions of tons of CO_2 into the atmosphere. The extent to which that potential is leveraged will be determined by our ability to overcome the technical and economic hurdles that confront this technology. It remains to be seen whether federal action – including potential regulatory requirements, like New Source Performance Standards for electric power plant GHG emissions and the US Department of Energy's research and development efforts in carbon capture – will spur sufficient interest and investment to make it a commercial technology. This chapter explains the process of carbon capture and storage/utilization in detail, describes the state of projects throughout the United States, and details the regulatory backdrop for this technology.

Chapter 8 — Retire Aging Power Plants

Although retiring aging coal-fired EGUs is becoming more and more prevalent, these decisions remain a sensitive topic. Despite the likely environmental benefits, retiring an aging EGU has the potential to produce significant economic impacts for utility ratepayers, companies, and the community where the unit is located. However, when weighed against various policy alternatives, retiring an aging EGU may be a lower-cost solution to the challenge of emissions reductions and worthy of inclusion in a state's Clean Power Plan compliance strategy.

There are various regulatory contexts in which states can review proposals to close power plants. There are also numerous factors that can affect decisions to keep a plant running or to retire it, including forward-looking market considerations, environmental regulatory requirements, and the ability to recover past plant-related investments. States that consider plant closure as a compliance option will have to consider these issues, as well as the varying degree to which these factors support such a decision. However, states that do engage in this effort will be better prepared to evaluate a wider array of potential compliance options and better able to strike their preferred balance between costs and other policy goals, including the most affordable and reliable compliance scenarios allowable under the EPA's Clean Power Plan. This chapter explores the various decision metrics that affect whether a unit is retired and provides examples of how retirement decisions have been carried out in select jurisdictions.

Chapter 9 — Switch Fuels at Existing Power Plants

An option for reducing CO_2 emissions from EGUs is to switch to a lower-emitting fuel. Fuel switching is perhaps the most familiar and most proven method for reducing GHG emissions from existing EGUs. The technological challenges are familiar and manageable, the co-benefits can be substantial, and the costs are generally lower than for other technology options. This chapter details three distinct strategies to accomplish fuel switching: using a lower-emitting backup fuel and decreasing the use of a higher-emitting primary fuel, blending or co-firing a lower-emitting fuel with a higher-emitting fuel, or repowering the

EGU to accommodate the use of a lower-emitting fuel not previously used.

Fuel switching in its various forms offers a proven emissions reduction strategy that will be feasible to a lesser or greater extent for many covered sources. Literally thousands of EGUs in the United States already have the capability to fire multiple fuels, and many more could be candidates for a repowering project. The primary limitation on this strategy is not technical, but economic. Most EGUs that are not already using low-emitting fuels as a primary energy source are using higher-emitting fuels for economic reasons. Fuel switching could increase the operating costs, and possibly add capital costs, for these sources. However, the underlying economics will change when new mandatory CO_2 emissions limits are in place. Generation owners will then want to reconsider the relative costs of different fuels and determine if fuel switching is their best compliance option.

Chapter 10 — Reduce Losses in the Transmission and Distribution System

Electricity losses occur at each stage of the power distribution process, beginning with the step-up transformers that connect power plants to the transmission system, and ending with the customer wiring beyond the retail meter. These electricity losses are often referred to generically as "line losses," even though the losses associated with the conductor lines themselves represent only one type of electricity loss that occurs during the process of transmitting and distributing electricity. System average line losses are in the range of six to ten percent.

Reducing line losses in the electrical transmission and distribution system is a readily available option to enhance electrical efficiency and reduce generation-related emissions. Advances in technology and understanding have made significant efficiency gains possible through investments in improved grid components and, on the demand side, in load management at peak levels. As with several other options, the primary limitation on this strategy is economic, not technical. It is essential that new system builds take advantage of more efficient components.

Upgrades and/or replacement of the broad electrical distribution infrastructure now in place, however, will remain a significant obstacle. Changes in the electric power industry, declining electrical demand in many areas, and increasingly competitive distributed generation alternatives, may make the financing of new, more efficient grid infrastructure challenging. The advent of mandatory CO_2 emissions reduction requirements will improve the payback of such improvements, but will simultaneously motivate more efficient end-use equipment and clean distributed generation as well. Each component of the distribution system can be optimized to reduce line losses. This chapter discusses each component, and how equipment choices can affect efficiency and, by extension, GHG emissions.

Chapter 11 — Establish Energy Savings Targets for Utilities

"Energy efficiency" is a term used to describe technologies, equipment, operational changes, and in some cases behavioral changes that enable our society to enjoy equal or better levels of energy services while reducing energy consumption. Energy efficiency is a low-cost, low-risk resource that compares favorably to all supply-side alternatives. It is also a proven and effective means of reducing air pollution emissions, increasingly recognized and encouraged by the EPA and state air pollution control agencies. By leveraging several policy mechanisms, chiefly an Energy Efficiency Resource Standard, states can make significant reductions in CO_2 emissions while stimulating job growth and their economies.

This chapter focuses on policies that establish mandatory energy savings targets for electric utilities, the achievement of which is generally funded through revenues collected from customers themselves. Ratepayer-funded energy efficiency programs have expanded significantly over the past decade, yielding significant economic and environmental benefits. Nevertheless, the potential to achieve even greater energy savings exists across the country, perhaps even more so in states that have a shorter history with energy efficiency programs or have historically invested less money in energy efficiency.

Chapter 12 — Foster New Markets for Energy Efficiency

This chapter builds on Chapter 11 by focusing on policies that create or expand the opportunities for voluntary, market-based transactions that promote energy efficiency (i.e., technologies, equipment, operational changes, and in some cases behavioral changes that help produce equal or better levels of energy services while reducing energy consumption) as an alternative or supplement to government-mandated programs or regulatory requirements.

Investments in end-use energy efficiency have proven to be a low-cost option for states to achieve carbon reductions, and this option provides the longest and most robust list of co-benefits of all the options described in this document. But despite the fact that energy efficiency provides numerous benefits to utilities, their customers, and society, this option is frequently undervalued and underused.

This chapter discusses encouraging or facilitating the use of energy auditing and energy savings contracts between consumers and third-party energy service companies; improving consumer access to affordable private financing or providing tax incentives for energy efficiency improvements; creating voluntary energy consumption labeling and benchmarking programs for appliances and buildings; and allowing energy efficiency to compete for compensation in wholesale electricity markets.

Chapter 13 — Pursue Behavioral Efficiency Programs

Some energy efficiency programs use information dissemination, social interaction, competition, and/or potential rewards, rather than direct financial incentives, as the primary mechanisms for changing energy consumption behavior. These programs are known as "behavioral energy efficiency programs." To date, most energy efficiency programs have focused on realizing savings through technical approaches, such as replacements, upgrades, and modifications to equipment and buildings. However, program administrators are increasingly considering behavioral energy efficiency programs for inclusion in their portfolios, and these programs are becoming more mainstream. This chapter discusses in more detail the types, benefits, and limitations of behavioral energy efficiency programs, as well as states' experiences in addressing barriers to implementing them.

Chapter 14 — Boost Appliance Efficiency Standards

Appliance standards set minimum energy and water efficiency requirements for selected appliances and equipment — where cost-effective — and prohibit the production, import, or sale of appliances and equipment that do not meet those requirements. Although states cannot set efficiency standards for federally regulated products, they can and do adopt standards for products not covered by federal standards. Appliance standards have been one of the most cost-effective policies to generate significant energy and emissions reductions in the United States and could be an effective policy option to reduce CO_2 at the lowest possible cost. This chapter discusses in more detail the benefits to be gained from appliance standards, as well as states' experiences in addressing political and other barriers to implementation.

Chapter 15 — Boost Building Energy Codes

Approximately half of US energy use is in buildings, and much of this is consumed in the heating, cooling, and lighting of those buildings, all of which are addressed by building energy codes. Building codes establish mandatory requirements for the building shell, mechanical equipment, and lighting systems, which can have a very significant impact on building energy use and associated carbon emissions.

Building codes establish minimum efficiency requirements for new and renovated residential and commercial buildings. They lock in future energy savings during the building design and construction phase, rather than through later, more expensive renovations. Building codes also capture energy savings that are more cost-effective than the more limited retrofit opportunities that are available after a building has been constructed. Up-to-date energy efficiency codes can reduce building energy use dramatically; the most recent national code would reduce usage by about 30 percent below conventional building standards. Innovative "Zero Net Energy" codes can reduce net building use to zero. This chapter analyzes different types of building codes and other mandatory building efficiency policies and provides examples of programs and codes that cities and states have enacted.

Chapter 16 — Increase Clean Energy Procurement Requirements

Increasing the proportion of zero- and low-emissions resources in the electricity supply portfolio is one of the most promising ways to reduce carbon emissions from the levels currently produced by a fossil-fuel-heavy portfolio. Although energy efficiency provides the most cost-effective path with the longest list of co-benefits for meeting energy portfolio requirements, the technical potential for renewable technologies is considerable, especially for wind and solar, exceeding existing electric demand by orders of magnitude.

Procurement policies for electric utilities and competitive retail suppliers to acquire clean energy have been found to be very successful in accelerating deployment of clean energy technologies on a large "utility" scale. The last decade has been marked by the widespread introduction and expansion of renewable and clean energy procurement requirements, in particular Renewable Portfolio Standard policies, which now exist in a majority of states.

In most cases, regulated entities have shown a willingness and ability to comply with procurement requirements, and evidence suggests that where policies have caused retail electricity rates to increase these increases have been less than two percent. Program costs are generally driven by three factors: (1) the availability of clean resources; (2) the targets themselves; and (3) the availability of cost-mitigation strategies, such as an alternate compliance payment framework. This chapter explores a variety of policies that can be adopted to increase clean energy procurement. Also featured in this chapter are various regulatory frameworks that can be used as a complement to procurement frameworks to help reduce barriers to participation by independent power producers.

Chapter 17 — Encourage Clean Distributed Generation

"Distributed generation" (DG) is a widely used term that has been defined and interpreted in different ways across federal, state, and local jurisdictions. For the purposes of this document, clean DG refers to generating facilities with a rated capacity of 20 megawatts or less that are interconnected to the distribution system. This is intended to encompass all DG technologies that contribute to reducing GHG emissions in the power sector, such as solar photovoltaics, wind, biomass, anaerobic digestion, geothermal, fuel cell, and efficient combined heat and power technologies.

Because clean DG can displace the need for some fossil fuel-based, central station generation, it can be a viable option for complying with the Clean Power Plan. Most forms of DG also reduce emissions of other air pollutants. The benefits of clean DG are amplified to some extent by the fact that it avoids most or all of the transmission and distribution line losses that are associated with central station generation. DG systems can also be deployed in much smaller increments than utility-scale, central station generation, which reduces the risk and expense of developing more capacity than utility customers need.

Clean DG technologies are cost-competitive in some states today and are becoming increasingly competitive as technology costs decline, technology performance improves, grid modernization better allows the potential value of local DG to be captured, and state policies toward DG evolve. This chapter discusses how improvements in interconnection policies, effective tax and incentive policies, state policies preferring clean energy sources, such as Renewable Portfolio Standard policies, and the terms and conditions of tariffs and contracts can each contribute to increasing the deployment of clean distributed generation.

Chapter 18 — Revise Transmission Planning and Cost Allocation

Transmission lines are an essential component of the modern electric grid, but one that is perhaps little understood by many regulators as the lines themselves do not emit air pollution. Although transmission lines do not directly reduce GHG emissions, they enable many reliable and cost-effective choices that can reduce GHG emissions. Some of the low-emissions generation technologies, like wind, solar, and geothermal technologies, are already cost-effective (compared to fossil fuel generation technologies) when sited in optimal locations. However, if those optimal locations are far from load centers, transmission is a necessary complement to developing these resources. In some cases, the best sites for these technologies simply cannot be developed at all unless new transmission lines are built. And in other cases, improvements to the transmission system are necessary (or will be) to enable grid operators to integrate greater amounts of variable energy resources while maintaining system reliability.

Transmission planning processes can identify the best options for tapping the potential of low-emitting electric generation resources, while maintaining reliability and containing costs. Some transmission options that facilitate GHG emissions reductions will make economic sense, even if those reductions are not needed or are considered to have no value. But other options may only be considered cost-effective when the value of GHG emissions reductions is considered along with all other relevant costs and benefits. Good planning processes will not only consider all of the costs and benefits of transmission, including GHG benefits, they will also allocate costs fairly to all beneficiaries. In addition, they will identify the potential to meet customer demand through non-transmission alternatives, such as energy efficiency, which also reduce GHG emissions and are more cost-effective. This chapter discusses the issues and challenges affecting transmission planning and cost allocation, regulatory rules affecting these issues, and how states have addressed these issues.

Chapter 19 — Revise Capacity Market Practices and Policies

In some parts of the United States, "capacity markets" have been established as a mechanism for promoting competition in the electric power sector while ensuring reliable electric service. This chapter explains what capacity markets are, where they have been instituted, and – most importantly – how capacity market rules can have an impact on GHG emissions.

It is important to understand that the existence of a capacity market does not, by itself, imply reduced GHG emissions, and establishing a capacity market is not necessarily a policy tool for reducing emissions. However, where capacity markets exist, the specific practices and policies (i.e., market rules) can and do affect GHG emissions, so it is legitimate to consider capacity market rule reforms as a tool for supporting and enhancing other GHG emissions reduction strategies. This chapter identifies some capacity market rules that support emissions reductions and should be emulated, as well as some market rules that can inhibit emissions reductions and should be changed.

Chapter 20 — Improve Integration of Renewables Into the Grid

The universal availability of reliable, affordable electric service is considered to be a high priority throughout the United States because of the central role that electricity plays in public health, social welfare, and economic productivity. This chapter focuses on a suite of policies and mechanisms that can help ensure continued electric system reliability as the electric system changes to include a higher penetration of variable energy resources, particularly wind and solar EGUs.

These policies and mechanisms do not reduce GHG emissions in and of themselves, but they are necessary complements to many GHG-reducing actions because they enable the electric system to continue to function reliably with a portfolio of much lower GHG-emitting generation resources.

Chapter 21 — Change the Dispatch Order of Power Plants

One option for reducing CO_2 emissions in the power sector is to change the order in which power plants are dispatched, so lower-emitting power plants operate more frequently and higher-emitting power plants operate less frequently. A number of different policies can accomplish this goal. Some jurisdictions have adopted emissions pricing policies to reduce CO_2 emissions. These policies include emissions taxes or, more commonly in the United States, emissions trading programs that directly or indirectly place a price on emissions. An alternative to emissions pricing that also shifts the dispatch order toward lower-emitting EGUs is "environmental dispatch." Environmental dispatch is a policy in which the system operator explicitly considers environmental criteria (primarily air pollution emissions) when making dispatch decisions, even if the environmental impacts do not lead to an actual regulatory compliance cost. These policies, implementation experiences, and associated GHG reductions are discussed in detail in this chapter.

Chapter 22 — Improve Utility Resource Planning Practices

This chapter focuses on the potential for utility resource planning processes to support the efforts of states to reduce GHG emissions from the electric power sector. At the heart of this discussion is a particular type of planning process, called integrated resource planning. This particular process, as well as any plan produced by the process, is commonly referred to by the acronym IRP. An IRP is a long-range utility plan for meeting the forecasted energy demand within a defined geographic area through a combination of supply-side resources (i.e., those controlled by the utility) and demand-side resources (i.e., those controlled by utility customers). Generally speaking, the goal of an IRP is to identify the mix of resources that will minimize future energy system costs while ensuring safe and reliable operation of the system. This chapter explores IRP policies and the process to implement them, as well as implementation scenarios from around the United States.

Chapter 23 — Improve Demand Response Policies and Programs

Demand response (DR) refers to the intentional modification of electricity usage by end-use customers during periods of system stress, system imbalance, or in response to market prices. DR policies and programs were initially developed to help support electric system reliability by reducing load during peak hours. More recently, technical innovations have made it possible to expand DR capabilities to provide an array of ancillary reliability services. DR is also capable of promoting overall economic efficiency, particularly in regions that have wholesale electricity markets. DR programs can mitigate the cost impacts of GHG reduction efforts to make them more acceptable to consumers and policymakers. In addition, under certain circumstances, DR programs can reduce net emissions of GHGs and other air pollutants from existing sources. Finally, and perhaps even more importantly, DR programs can facilitate the use of various emissions reductions strategies, such as the integration of renewable energy into the grid, while ensuring reliable electric service. This chapter reviews the many forms of DR and the scale of energy savings and emissions reductions it can produce.

Chapter 24 — Adopt Market-Based Emissions Reduction Programs

One of the ways to reduce GHG emissions is to effectively place a price on emissions, and then rely on market forces that incentivize and reward innovation, competition, and customized solutions to reducing costs. A price can be directly imposed through a tax (as discussed in Chapter 25), or indirectly imposed through a market-based program, such as those described in this chapter. The most familiar market-based program is the cap-and-trade system. Cap-and-trade systems have been successfully used for two decades to control air pollution from electric power plants in the United States. These systems can be simple, transparent, and relatively straightforward to implement. This chapter explains market-based emissions reduction programs types, describes programs that have been implemented worldwide, and provides examples of successful programs in the United States.

Chapter 25 — Tax Carbon Dioxide Emissions

Pricing mechanisms can be an important element in any effort to reduce electric-sector GHG emissions. Pricing will be most effective when combined with related policies to encourage the use of other, less carbon-intensive resources. Policies that provide a real or implicit price of carbon internalize the cost of carbon emissions and can make renewables or other low-carbon resources more cost-competitive with other energy sources. This in turn creates incentives for producers and consumers to invest in low-GHG products, technologies, and processes. Policies that provide a carbon price can also serve as a source of revenue for funding low-carbon technologies and programs. This chapter explores different types of carbon taxes, and provides examples of how they have been implemented worldwide.

Chapter 26 — Consider Emerging Technologies and Other Important Policies

The 25 previous chapters offer a wide array of options to reduce GHG emissions from the electric power sector through existing technology-based and policy-oriented solutions. The electric sector is undergoing dramatic change, however, morphing from a one-direction analog system with centralized EGUs providing electricity to end-users through radial transmission and distribution networks, where supply is managed to meet demand, into a digital, distributed network system, where both supply and demand are managed through two-way communications and smart devices. These changes will profoundly alter the electric power system. Although the outcomes of these changes are not possible to fully predict, there are nonetheless technology and policy trends and developments that are increasingly evident. Some may not achieve significant penetration in the existing electric power system for a decade or more, but others are already becoming widely commercialized. It is important to consider these developments in air quality planning processes. This chapter provides a brief introduction to several of these emerging technology and policy considerations, including electricity storage, smart grid, electric vehicles, device-to-device communications (often called the "internet of things"), the water-energy nexus, reliability, rate design and pricing, new utility business models, carbon offsets, and multi-pollutant planning.