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Integrating Energy and Environmental Policy

RAP
Energy solutions for a changing world

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Integrating Energy and Environmental Policy

Authors

Kenneth Colburn, John Gerhard, David Moskovitz, Rebecca Schultz

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Abbreviations and Acronyms

BERR Department for Business, Enterprise and Regulatory Reform (UK)

CACJA Clean Air-Clean Jobs Act

CCS Carbon Capture and Sequestration

CEMS Continuous Emissions Monitoring Systems

CO_2 Carbon Dioxide

CSWD Commission Staff Working Document

DECC Department of Energy and Climate Change (UK)

DEFRA Department of Environment, Food and Rural Affairs (UK)

DG Directorate General

DG CLIMA Directorate General Climate Action

DG ENER Directorate General for Energy

DG ENTR Directorate General for Enterprise and Industry

DG ENV Directorate General Environment

DG TREN Directorate General Transport and Energy

DNR Department of Natural Resources

EPA Environmental Protection Agency

ERCOT Electric Reliability Corporation of Texas

ETS Emissions Trading System

EU European Union

EuP Energy-Using Product

FCM Forward Capacity Market

FERC Federal Energy Regulatory Commission

FGD Flue Gas Desulfurization

FYP Five Year Plan (China)

GHG Greenhouse Gas

HEDD High Electric Demand Day

IIASA International Institute for Applied Systems Analysis

ISO-NE Independent System Operator of New England

ISSG Inter-Service Steering Group

MOU Memorandum of Understanding

MW Megawatt

NAAQS National Ambient Air Quality Standards

NARUC National Association of Regulatory Utility Commissioners

NECPUC New England Conference of Public Utility Commissioners

NEDRI New England Demand Response Initiative

NESCAUM Northeast States for Coordinated Air Use Management

NO_x Nitrogen Oxides

OTC Ozone Transport Commission

PSC Public Service Commission

PUC Public Utility Commission

RGGI Regional Greenhouse Gas Initiative

RTPS Raichur Thermal Power Station

SERC State Electricity Regulatory Commission

SIP State Implementation Plan

SO_2 Sulfur Dioxide

About the Global Power Best Practice Series

Worldwide, the electricity sector is undergoing a fundamental transformation. Policymakers recognize that fossil fuels, the largest fuel source for the electricity sector, contribute to greenhouse gas emissions and other forms of man-made environmental contamination. Through technology gains, improved public policy, and market reforms, the electricity sector is becoming cleaner and more affordable. However, significant opportunities for improvement remain and the experiences in different regions of the world can form a knowledge base and provide guidance for others interested in driving this transformation.

This Global Power Best Practice Series is designed to provide power-sector regulators and policymakers with useful information and regulatory experiences about key topics, including effective rate design, innovative business models, financing mechanisms, and successful policy interventions. The Series focuses on four distinct nations/regions covering China, India, Europe, and the United States (U.S.). However, policymakers in other regions will find that the Series identifies best — or at least valued — practices and regulatory structures that can be adapted to a variety of situations and goals.

Contextual differences are essential to understanding and applying the lessons distilled in the Series. Therefore, readers are encouraged to use the two supplemental resources to familiarize themselves with the governance, market, and regulatory institutions in the four highlighted regions.

The Series includes the following topics:

1. New Natural Gas Resources and the Environmental Implications in the U.S., Europe, India, and China
2. Policies to Achieve Greater Energy Efficiency
3. Effective Policies to Promote Demand-Side Resources
4. Time-Varying and Dynamic Rate Design
5. Rate Design Where Advanced Metering Infrastructure Has Not Been Fully Deployed
6. Strategies for Decarbonizing the Electric Power Supply
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11. Integrating Renewable Resources into Power Markets

Supplemental Resources:

12. Regional Power Sector Profiles in the U.S., Europe, India, and China
13. Seven Case Studies in Transmission: Planning, Pricing, and System Operation

In addition to best practices, many of the reports also contain an extensive reference list of resources or an annotated bibliography. Readers interested in deeper study or additional reference materials will find a rich body of resources in these sections of each paper. Authors also identify the boundaries of existing knowledge and frame key research questions to guide future research.

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Foreword

In this paper, my colleagues make the case that "greater integration and coordination of energy and environmental regulation can improve both environmental and energy outcomes – as well as citizens' quality of life and economic wellbeing." It is a subject that is near and dear to my heart. For most of my own career, I've tried to practice precisely what this paper preaches. I've had the good fortune to collaborate with others who understand the value of integrated decision-making, and I've seen the kinds of results that the authors assert are possible with this approach.

I worked as an air pollution regulator at the Department of Natural Resources (DNR) in the state of Wisconsin (US) until 1997, when I took a job as an "energy sector specialist," a newly created position by then-Secretary George Meyer. Secretary Meyer believed in integrated decision-making and wanted a staff person who would seek to understand not just the environmental impacts of electric utilities, but also the business and regulatory environment in which they operate.

Over the next ten years, I worked cooperatively with Wisconsin's electric utilities to promote integrated decision-making, emphasizing two of the recommendations contained in this report. First, we focused on comprehensive, multipollutant approaches to regulation. Second, we adopted forward-looking planning approaches that looked beyond the minimum requirements of current regulations. This work was guided by voluntary agreements that I negotiated with two of Wisconsin's utilities in 2002.

Wisconsin's largest utility signed a Multi-Emission Cooperative Agreement with DNR in which it agreed to invest $400 to $600 million over ten years to reduce sulfur dioxide, nitrogen oxides, and mercury emissions from its fleet of power plants. This emissions reduction plan was part of a larger $6 billion capacity expansion plan. These plans allowed the utility to increase its generating capacity by 50 percent at the same time that its system-wide emissions of nitrogen oxides, sulfur dioxide, and mercury decreased by roughly 70 percent. As a result, the utility is well positioned to comply with new federal air pollution rules. The benefits of long-term planning and multipollutant approaches are also evident from the company's business record. While the plan was being implemented, earnings per share and dividends paid to shareholders increased every year. Last year, the company achieved its best customer satisfaction ratings in more than a decade and was named the most reliable utility in the US midwest by an independent consulting firm.

Another Wisconsin utility signed a similar voluntary agreement with DNR that achieved similar results, albeit on a smaller scale. The utility agreed to undertake an analysis of options for reducing air pollution from a specific generating station, utilizing multipollutant control strategies. This analysis ultimately led to a decision by the company to switch from coal to natural gas at this facility, which virtually eliminated sulfur dioxide and mercury emissions, and reduced particulate emissions by 91 percent, emissions of nitrogen oxides by 19 percent, and carbon dioxide emissions by 13 percent on a per-MWh basis. Like the utility mentioned above, this utility now has a head start on compliance with new federal air pollution rules. And over this same time period, the utility doubled the market value of its assets, increased the dividend paid to shareholders every year, and produced record earnings in four of the last five years. Furthermore, the utility's electric service reliability was ranked No. 1 in a nationwide utility industry survey based on average customer outage times in 2011.

These successful examples of long-term, multipollutant planning would not have been possible had environmental regulators worked in isolation or been at odds with energy regulators. Fortunately, Wisconsin's laws spelled out a very detailed process and accelerated timeline for coordinated interagency review and approval of proposed large utility projects, including pollution control projects. So throughout the development and implementation of these plans, utility regulators at the Public Service Commission (PSC) of Wisconsin scrutinized the utilities' environmental planning decisions and investments to ensure that they were prudent and in the public interest. I witnessed this firsthand while serving as staff to the Commission from 2008 to 2011. The PSC also oversaw utility compliance with new laws requiring investments in energy efficiency and renewable energy that led to additional air quality improvements. And this integration of environmental and energy goals was not the result of mere serendipity, either. As recommended in this report, the State of Wisconsin had enacted laws requiring the PSC and DNR to ensure coordination of energy efficiency and renewable resource programs with air quality programs in order to maximize the benefits that can be realized.

In short, regulators in Wisconsin (and the public they serve) are benefitting today from what the authors call "a virtuous cycle of interdependence and support that leads to more effective outcomes for both energy reliability and affordability, as well as public health and environmental quality."

These examples focus on events in Wisconsin, but they are merely illustrative of similarly positive outcomes that are happening throughout the world. This paper explores what it means to integrate energy and environmental decisions, explains why it is important, and gives concrete examples of how it can be accomplished. Examples from China, the European Union, India, and the United States are provided to show how integration is happening throughout the world.

Integration is happening, to be sure. But it is still not the norm. What RAP hopes to accomplish with this paper is to spread the word about the potential benefits of integrated decision-making and to offer some concrete steps that lawmakers and regulators can adopt to realize this potential. We envision a day in the not-too-distant future when integration of energy and environmental regulation has become so commonplace that regulators who pick up this report will wonder why anyone thought it needed to be written in the first place.

John Shenot
Associate
Regulatory Assistance Project

"What we've got here is a failure to communicate."
— Cool Hand Luke, 1967

"If we don't hang together, we shall surely hang separately."
— Benjamin Franklin

1. Introduction

Energy issues are environmental issues, and environmental issues increasingly are energy issues.[1] This link is inescapable: energy decisions have profound environmental and public health impacts, and energy-related emissions are changing the heat balance of Earth. The purpose of this paper is to demonstrate that greater integration and coordination of energy and environmental regulation can improve both environmental and energy outcomes – as well as citizens' quality of life and economic wellbeing – and to provide some advice and guidance for moving effectively in this direction.

Energy and environmental agencies routinely make decisions that have significant consequences for the other sector, but they often do so without adequate recognition of the interconnections to or adequate knowledge of the complexities of the changing science, technology, and policy of the other sector. These consequences may be unintentional but nonetheless can result in harm to public health and welfare. Lack of awareness by energy and environmental regulators of one another's responsibilities, concerns, and procedures – coupled with segregated institutional infrastructures evolving from distinct statutory authority and developed over decades of case law and past-practice – are primary causes of this disconnect. In an era of increasingly constrained natural, human, and financial resources, it is time for this to change.

For developing countries in the early stages of establishing their institutions and regulatory regimes, there is a unique window of opportunity now to recognize these shortcomings and build in coordination from the ground up. The severity of environmental degradation and rapid growth in energy consumption in China, for instance, has helped to cultivate strong support among its central leadership for environmental concerns. As a result, China has made notable progress in recent years integrating environmental and conservation priorities into energy decision-making. This paper proposes a number of principles and recommendations intended to help policymakers ensure optimal resource deployment across competing objectives, which may be especially useful in jurisdictions without long-entrenched regulatory traditions.

The generation of electric energy is, of course, only one component of global energy use. Other notable energy-consuming sectors include transportation and buildings, primarily through the combustion of liquid and gaseous fuels. All have substantial environmental impacts. In most countries, however, the electric power sector is the largest stationary source of air pollution. In addition, increasing electrification of the transportation sector will make it more difficult for the power sector to achieve environmental improvement while simultaneously maintaining reliability. Furthermore, in many nations this sector is in the early stages of restructuring (or in some cases, re-restructuring). Experience around the world demonstrates that modifying energy paradigms can create significant environmental opportunities and risks. Happily, there are synergistic solutions that can address the issues faced by both energy and environmental disciplines. Energy efficiency, for instance, can effectively and economically address the need for energy services with far less economic cost and environmental impact than other approaches. As such, it may be one of policymakers' and

1 Although the term "energy" is used throughout this paper, its primary focus is on the power sector (i.e., the electric utility industry). Many of the benefits of integrating environmental and energy decision-making, however, hold true for other energy-related sectors, including oil, natural gas, and renewable energy production and transportation, residential, commercial, and industrial end uses.

regulators' most powerful tools.

This paper poses three main questions to investigate the integration and coordination of energy and environmental regulation – or lack thereof:

- What do we mean when we urge regulators, policymakers, and lawmakers to integrate energy and environment?
- Why is it increasingly important to make the integration of energy and environment a priority?
- How can regulators address integration – what concrete actions can be taken, and what policies should be pursued?

2. What?

What do we mean when we urge regulators, policymakers, and lawmakers to integrate energy and environment? Stated most simply, integration of energy and environment means that energy policymakers and regulators are aware of the environmental consequences of the decisions they make, and they are empowered to act on that knowledge in ways that help meet relevant environmental goals. Equally, integration also means that environmental policymakers and regulators are aware of the impact of their decisions on the energy sector, and they are empowered to act on that knowledge in ways that support energy-related goals and policies.

Given that energy and environmental regulators often have what appear to be separate and distinct responsibilities – energy regulators to ensure reliable and affordable electric service, and environmental regulators to protect human health and welfare – it is sometimes easy to see them as occupying entirely separate spheres. In fact, a signal premise of this paper is that this is precisely what has happened in many jurisdictions. When we urge regulators, policymakers, and lawmakers to integrate energy and environment, we are urging them to look past the thin, often artificial veneer of separation and see the real, fundamental linkages that characterize the two fields.

Integration means that energy and environmental regulators are aware of one another's disciplines; they grasp the depth, complexity, and interrelatedness of their counterpart's subject matter and issues; they take the time to appreciate their counterpart's concerns, goals, and mandates; and their practices and decisions take their counterpart's concerns into consideration to the greatest extent possible.[2] Integration means that energy and environmental regulators are empowered by their respective constitutive authorities to work together and to act in concert toward common goals; not only are they empowered to do so, but they are expected or required to do so. Integration means that energy and environmental regulators organize their respective administrative apparatus to foster, encourage, and support interagency activities in support of interagency goals; energy offices and environmental offices communicate regularly, are closely intertwined, and are mutually supportive of each other's efforts.[3]

Each of these elements of integration contributes to and further perpetuates integration. When energy and environmental regulators are empowered to work together and, in fact begin to do so, the respective entities become more aware of and knowledgeable about one another's issues and concerns. This deeper knowledge leads to better cooperation and more integrated operations. This dynamic can create a virtuous cycle of interdependence and support that leads to more effective outcomes for both energy reliability and affordability, as well as for public health and environmental quality.

2 For example, in the United States, one way to assure this kind of cooperation is to have a mandate written into statute so that decisions by energy regulators must consider environmental goals and decisions by environmental regulators must consider energy goals.

3 It remains a real obstacle in many jurisdictions that, even where agencies are willing to engage in these cooperative activities, they lack adequate staff to do these things, lack flexibility to change personnel, and lack sufficient revenue to hire specialists to help.

3. Why?

There are three main reasons it has become increasingly important to make the integration of energy and environment a priority issue. First, although energy and environment easily may be separated on a government organizational chart, in fact they are inextricably linked. The connections between the two are compelling and unarguable. Second, conditions have changed so profoundly since most energy and environmental institutions were structured that they fail to reflect modern realities. Today's resource decisions happen against a backdrop of mounting greenhouse gas (GHG) emissions and a power sector that has transformed from a regulated cost-based sector to one that incorporates competitive markets, new energy technologies, and emerging resource constraints. Management approaches need to reflect these trends. Finally, taking into account the linkages between energy and environment leads to more rapid and cost-effective results, as experience in both developed and developing countries is now demonstrating. From a pragmatic standpoint, we can no longer afford to manage these sectors in isolation from one another. The balance of this section will explore these three reasons in more depth.

A. Energy and Environment Are Linked in the Real World

Although energy and environment may be susceptible to separation conceptually, in the real world they are intrinsically and inextricably linked. The energy policy and investment choices that we make have profound environmental consequences. The focus of this paper is the electric power sector in particular, which has an enormous impact on the environment. Globally, the electricity sector represents approximately:

- 50 percent of sulfur dioxide (SO_2) emissions. This is a proportion that generally increases with the level of local or regional economic modernization. China's power sector, for example, accounts for about 55 percent of national SO_2 emissions, while in the United States that figure is closer to 70 percent. SO_2 emissions, in conjunction with those of nitrogen oxides (NO_X), lead to acid deposition and contribute significantly to fine particulate pollution that causes millions of premature deaths annually worldwide.[4,5]
- 30 percent of global emissions of NO_X. A dangerous pollutant itself, NO_X also reacts with organic compounds in sunlight to form ground-level ozone, which reduces agricultural productivity, stresses forest ecosystems, helps trap heat to the earth's surface, and triggers heart and respiratory problems that contribute to premature death.
- 40 percent of carbon dioxide (CO_2) emissions, the heat-trapping GHG primarily responsible for global warming.[6]
- A major source of anthropogenic emissions of heavy metals, such as mercury, of which 35 percent originate in the power sector, and the largest source of nuclear waste.[7]

These emissions have serious human health impacts worldwide. Mortality attributable to urban air pollution was estimated to exceed 1.34 million premature deaths in 2008, up from 1.15 million deaths in 2004 – an increase likely linked to rising concentrations of air pollution and growing urban populations, as well as improved data availability and methods employed.[8] This represents about 2.4 percent of all deaths globally.[9] Furthermore, particulate matter is estimated to cause about 8 percent of deaths from lung

4 Smith et al, 2011.

5 Lu et al, 2010.

6 International Energy Agency, 2011.

7 Pirrone et al, 2010.

8 World Health Organization, 2011.

9 World Health Organization.

cancer, 5 percent of deaths from cardiopulmonary disease, and about 3 percent of deaths from respiratory infections globally.[10]

Environmental decisions can have similarly profound impacts on energy policy, especially within the electricity sector. Recent Environmental Protection Agency (EPA) regulations have had a heavy impact on emissions from power plants. Some in the United States, in fact, have accused the EPA of an "unrelenting power grab" to seize control of energy.[11,12] Even within the US power sector, opinions vary as to whether the EPA's actions will adversely affect reliability and result in substantial rate increases, or instead serve to redirect the nation's electric sector toward the "new energy economy" of the future.[13]

Despite this clear interrelatedness, energy and environmental regulators often operate independently of each other. Worse, they often work without regard for each other's interests. In their normal course of business (e.g., rate cases, resource planning, system dispatch, and so on), for example, US energy regulators typically do not take into account air pollutant emissions, even though those emissions are the fundamental public health drivers of environmental regulators under the Clean Air Act.[14] Instead, emissions typically are considered to be "externalities." Meanwhile, environmental regulators in the United States develop National Ambient Air Quality Standards (NAAQS) under the same Clean Air Act without regard for reliability or cost impacts[15] – two fundamental concerns of public utility commissions nationwide.

This schism is counterproductive because, at bottom, energy and public health each represent key pillars of quality of life. One or the other alone does not serve the public interest; both are necessary. The compounding impact of their segregation is evident today. Environmental regulation that is not mindful of energy concerns adds to consumers' already expensive annual energy bill – over $1 trillion annually in the United States, of which some $350 billion is for retail electricity.[16] Conversely, energy decisions that do not account for the public health impacts associated with pollution exacerbate health care costs – now over $2.5 trillion in the United States annually (not counting premature deaths, lost productivity, and lost welfare).[17]

B. New Conditions Make Integration More Compelling Than Ever

Regulation of energy and environment are constantly changing. Indeed, it is the fact that each is changing without regard to the other that underscores the importance of greater coordination. At the macro level there are four emerging trends that drive the need to integrate energy and environment:

- The changing structure of power sector and markets;
- Climate change;
- The emergence of natural gas; and,
- The energy and water nexus.

i. Changing Structure of Power Sector and Markets

The basic structure of environmental regulation around much of the world was developed during a time when the power sector was a vertically integrated, cost-

10 World Health Organization, 2009.

11 Driessen, 2011.

12 See http://www.nicholas.duke.edu/thegreengrok/powergrab/

13 Edison Electric Institute and American Bar Association sponsored a conference on May 17, 2011 entitled "EPA Regulation of Electric Generation: Train Wreck or Clearing the Tracks for the New Energy Economy?" See also http://www.stopthetrainwreck.com/

14 Siting and construction of new energy facilities often requires an environmental impact assessment under U.S. federal and state statutes (e.g., the National Environmental Policy Act, 42 USC Sections 4321-4347). Such assessments typically assemble and present information relevant to the decision and may also explore alternative options. However, decision-makers can still proceed with a project even if an environmental impact statement predicts that it will create negative environmental impacts.

15 However, Clean Air Act Section 108(b) does require that upon issuing an NAAQS, the EPA must simultaneously provide information on air pollution control techniques and their cost of installation and operation, energy requirements, emission reduction benefits, and environmental impacts, and that such techniques include alternative fuels, processes, and operating methods.

16 U.S. DOE/EIA, 2011.

17 U.S. Census Bureau, 2012.

based, regulated monopoly. The cost of pollution control was passed on to consumers, investment decisions for major generation projects had substantial public scrutiny, and decisions relating to retirement of plant were based on cost-of-service considerations. The design of major environmental and pollution control policies never had to take into account how they would interact with competitive markets to create winners and losers, because gains and losses were simply passed on to consumers dollar-for-dollar.

Meanwhile, there has been and continues to be a revolution in the structure of the power sector. Major segments of the industry are now fully competitive in many parts of the developed world. Many developing countries, such as China, are exploring ways to embrace market-based mechanisms in their power sectors. As a result, many traditional environmental policies can now have a very different and often negative effect.

Market pricing generally and the structure of capacity pricing in particular totally changes the economics of older, generally higher-polluting power plants. For example, an old largely depreciated coal plant may produce just enough revenue to cover its operating cost (e.g., 2 cents/kWh plus ½ cent/kWh to cover its mostly depreciated capital cost). When the same power plant operates in one of today's power markets, however, it receives the full market-clearing price (e.g., 6 cents/kWh). This power plant likely operates under lenient "grandfathered" emission limits that were set assuming the power plant would retire and be replaced with a cleaner power plant. But with its newfound profitability – partly the result of its relaxed environmental obligations – the power plant is likely to operate well beyond its expected retirement date. This has been the case in liberalized markets in the United States.

A second example relates to power markets that include capacity markets. Generators have argued successfully that capacity markets should not distinguish between new and existing power plants and that all generators should be paid the market-clearing price for capacity. Yet one of the distinguishing characteristics between new and existing generation is how much pollution they are allowed to emit. If environmental regulators were aware of how the power markets compensate generation, then they might logically conclude that, if all capacity gets paid like new capacity, all capacity should be subject to the same environmental standards as new capacity.

A further example again comes from markets. Energy markets are increasingly regional, and even interregional, in scope; the areas covered by these markets typically are much larger than has been the case historically. The expanding reach of markets increasingly corresponds to larger concentrations of generation further from load, coupled with longer transmission systems, and backed up by a robust gas supply network. When all of this is factored together, focusing on emissions from sources in a small area (e.g., one state) clearly is inadequate to address air quality challenges that can be regional or interregional in character. High-emitting sources of power may be not only remote from load, they may purposefully locate outside an air quality control area in order to extract a regulatory advantage. Meanwhile, the load centers in downwind states are adversely impacted by emissions from polluting generation in upwind states. This is commonly referred to as "leakage," a problem of concern to many states. The practical effect of these market developments is that it can become harder, if not impossible, for downwind states to meet air quality objectives.

Finally, we can look to issues that arise regarding the design of cap-and-trade programs for pollutants. There are two basic ways in which emissions allowances can be distributed in cap-and-trade programs: by giving them to sources (often referred to as "free allocation") or by forcing sources to buy them (typically at auction). When allocated free allowances, generators can either use them for compliance or sell them to other sources and potentially use the revenue to pay for the installation of emissions control equipment and related plant improvements. When auctioned by government jurisdictions, allowances are sold to the highest bidder, and the revenues are used for designated government purposes, including emission-reducing investments such as energy efficiency and conservation efforts. An effect of allocating allowances for free to sources is that dirtier generators pay no economic penalty compared to cleaner generators, an outcome at odds with environmental goals. Cap-and-trade programs must be designed with a clear understanding of how environmental regulation impacts energy operations, lest regulators design ineffective programs. The Regional Greenhouse Gas Initiative (RGGI) in the United States, where environmental and energy regulators worked together to develop an allowance auction system, is a good example of how these difficulties can be navigated effectively. RGGI is discussed in detail in Appendix A.

ii. Climate Change

Climate change is the ultimate reason energy and environmental policy and regulation must be coordinated closely. Without viable post-combustion control options for CO_2 emissions, regulators will have to seek pollution prevention for CO_2 through other approaches, including structural measures affecting the production and consumption of energy. The European Union (EU) offers some excellent examples of ways to approach integrating energy and environment decisions to combat climate change.

In 2007, the EU Heads of State and Government set a series of demanding climate and energy targets to be met by 2020, known as the "20-20-20" targets. These are:

- A 20-percent reduction in EU GHG emissions below 1990 levels;
- A 20-percent share of EU energy consumption from renewable resources; and
- A 20-percent reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

Setting multiple outcome-orientated targets, as in this case, can provide a framework within which regulators and civil servants can work as they devise multiple tools or policies that, taken together, achieve these targets in the most effective and efficient way. Ideally such a framework needs to include all key interrelated sectors. As such, one could argue that the above package of targets could be expanded to include outcome goals, bound by the same timeframe, to facilitate coordination with other areas such as air pollution reduction goals and water resource management.

In January 2008, the European Commission proposed binding legislation to implement the 20-20-20 targets. This "climate and energy package" was agreed upon by the European Parliament and Council in December 2008 and became law in June 2009. The core of the package comprises four pieces of complementary legislation:

- A revision and strengthening of the Emissions Trading System (ETS), the EU's key tool for cutting GHG emissions cost-effectively. A single EU-wide cap on emission allowances will apply from 2013 and will be cut annually, reducing the number of allowances available to businesses to 21 percent below the 2005 level by 2020. The initial free allocation of allowances will be replaced progressively by auctioning, and the sectors and gases covered by the system will be somewhat expanded.
- An "Effort Sharing Decision" governing emissions from sectors not covered by the EU ETS, such as transport, housing, agriculture, and waste. Under the Decision, each Member State has agreed to a binding national emissions limitation target for 2020, which reflects its relative wealth. The targets range from an emissions reduction of 20 percent by the richest Member States to an increase in emissions of 20 percent by the poorest. These national targets will cut the EU's overall emissions from the non-ETS sectors by 10 percent by 2020 compared with 2005 levels.
- Binding national targets for renewable energy, which collectively will lift the average renewable share across the EU to 20 percent by 2020.
- A legal framework to promote the development and safe use of carbon capture and sequestration (CCS). The EU plans to set up a network of CCS demonstration plants by 2015 to test its viability, with the aim of commercial uptake of CCS by around 2020.

The development of the above package benefited from internal coordination. A European Commission inter-service group – pulling together Commission officials, including those from Directorate General (DG) Environment, responsible for environmental regulation, and DG Transport and Energy (DG TREN), responsible for regulation relating to energy and transport – met between April 2005 and November 2006 to discuss targets for renewable energy overall, biofuels, electricity, and heating and cooling. The European Energy and Transport Forum[18] (representing energy businesses, networks and infrastructure managers, consumers, unions, environmental protection and safety organizations, and academics) was also consulted on the long-term strategy for renewable energies and on sectoral approaches.

In an attempt to ensure policy coherence, a joint integrated impact assessment[19] was carried out for the ETS

18 Commission Decision 2001/546/EC Commission Decision 2001/546/EC, of 11 July 2001, setting up a consultative committee to be known as the European Energy and Transport Forum [Official Journal L 195 of 19.7.2001].

19 SEC (2008) 85, Vol. II Commission Staff Working Document – Annex to the impact assessment. Document accompanying the package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020.

and for the proposals to promote renewable energies and to set binding national targets for renewable energy. Although it can be argued that the scope of this assessment could have been wider – with closer examination of the interplay with energy efficiency policy, for example – it was a considerable step beyond the usual approach of conducting separate impact assessments for each new piece of legislation. This comprehensive, single assessment covered a multitude of impacts, including those relating to air pollution (including costs and benefits), energy supply security, generation costs, electricity prices, and energy costs per sector.

Climate change is not a simple or passing phenomenon; its solution will require a complex, sustained response. The task of regulating GHG concentrations to stabilize the earth's planetary energy imbalance will be a challenge for generations to come and will require a comprehensive transformation in the way we make decisions about energy resources and use. To minimize costs over the long run, decision-making frameworks must guide investment and planning toward the capital infrastructure necessary to limit the environmental impacts of the power sector. And the EU effort marks a step in the right direction.

iii. Emergence of Natural Gas

The unprecedented rise and vast potential of unconventional natural gas is the latest development highlighting the deeply interconnected nature of energy and environmental issues. In the United States, gas supplies newly available through advances in drilling techniques have made gas-fired generation an economic alternative to coal, a trend that is spreading rapidly to other parts of the world. On the one hand, this substitution delivers environmental benefits associated with NO_X emission rates that are a fraction of those of coal, along with negligible SO_2, particulate, and mercury emissions. On the other hand, however, although natural gas combustion produces about half as much CO_2 per kWh as coal, it still represents a substantial source of carbon. Also, the reduced demand for US coal domestically may result in coal supplies being shipped to other countries to be used for power generation.[20] Low natural gas fuel prices, furthermore, make renewable generation less competitive by comparison, attracting capital investment to natural gas-fired units that might otherwise have been directed to wind and solar installations, and thus locking in fossil fuel technology.

Complicating matters further are environmental concerns about the drilling practices themselves. Hydraulic fracturing (or "fracking") has significant implications for water resources, both through the potential contamination of local waterways and aquifers and the large volumes of water used in the extraction process – each fracking job consumes from 3 to 5 million gallons of water, depending on site-specific geology and fracturing requirements.[21] Extraction can also result in fugitive emissions of methane at the wellhead; if not captured, they can represent a significant, direct source of GHG emissions and contribute to the formation of ground-level ozone. Ensuring that the current natural gas boom results in a net reduction in harmful emissions, safe and optimal use of water resources, and the use of natural gas-fired generation as a transition to a decarbonized power sector (instead of an obstacle to it) will require clear, science-based environmental policy and regulatory integration and oversight as new natural gas supplies come online globally.[22]

iv. Energy-Water Nexus

Water is an integral element of energy resource development and electricity generation; it is used for hydroelectric generation, for cooling in thermal generation, and for emissions scrubbing in thermoelectric generation.[23] Energy is an equally integral element of providing the water resources necessary for consumption, public health, and economic development; it is essential in the extraction and transportation of water supplies and the treatment of wastewater. Figure 1 illustrates the profound interdependency of water and energy, a nexus that Deloitte has laconically characterized as "No water, no energy. No energy, no water."[24] The combination of a growing population, warming temperatures, and the increasing frequency and duration of extreme weather events (such as severe storms and unusual droughts) makes the interconnection between water resources and power plants more important – and more tenuous – than ever.

20 Exports of coal and fuels on track to set record, 2012.

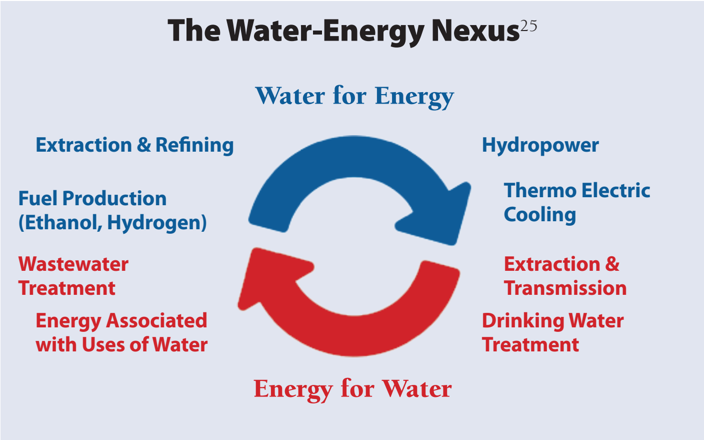
21 Bluestein et al, 2012.

22 For a full treatment of this issue, please refer to Bluestein et al, 2012.

23 U.S. Department of Energy, 2006.

24 Sarni & Stanislaw, 2012.

Figure 1



Carbon emissions from power plants contribute to the increasing atmospheric GHG concentrations at the root of these developments, drawing the nexus between power generation and water even tighter.

Water stress is already evident in many areas of the globe, as demands for water (e.g., drinking water supplies, agriculture, industrial uses, and so on) increase competition for declining freshwater resources. Energy and environmental regulators will need to work closely with each other to deal with the challenges posed by this nexus. Unfortunately, recognition of these challenges is only in the early stages; integrated water and energy resource planning has generally been lacking, and serious problems are already emerging. For more information on this issue see Appendix A.

C. Better Integration Works

Integrating energy and environmental decisions not only makes logical sense, there is a growing body of international experience demonstrating that it works and delivers the desired results – often more economically than when energy and environmental decisions are made independently. A few of the best examples from China, EU, and the United States are described here; more examples can be found in Appendix A.

i. China – Environmental Dispatch

One powerful example of the way in which China has aligned energy and environmental priorities is through a new approach to electricity dispatch scheduling. Historically, China's method of dispatching power plants has been based on contractual guarantees for minimum annual generating hours, a system devised to encourage investment during a period of chronic power shortages following the first phase of deregulation in the 1980s and 1990s.[26] Under this approach, tariff rates are set according to average plant costs, rather than marginal costs, as is the case in the United States and elsewhere. As a result, older, more polluting and inefficient power plants, which typically have the lowest average plant costs, are usually dispatched first to meet load. Problematic from a climate, air quality, and economic perspective, these power purchase contracts have been a major constraint in previous attempts to optimize dispatch.

In 2007, China took a significant step to address this problem by adopting a groundbreaking environmental dispatch rule. The new rule, developed jointly by energy and environmental regulatory authorities, establishes a mandatory dispatch order based on a combination of thermal efficiency and pollutant emissions. Whereas the standard international practice of least-cost dispatch seeks to minimize total variable costs on the system – which in practice are mostly fossil fuel costs – this approach aims to minimize total fossil fuel consumption.

Specifically, where environmental dispatch is applied, generating units are scheduled according to the following ranking:

- Non-dispatchable renewable energy generating units;
- Dispatchable renewable energy generation units;
- Nuclear power plants;
- Combined heat and power facilities that meet specified thermal efficiency criteria;
- Natural gas, coal-bed gas, and gasification generation units;
- Coal-fired power plants; within this category facilities are ranked by thermal efficiency, and plants with the same thermal efficiencies are ranked according to SO_2 emission rates; and finally
- Oil-fired generating facilities.[27]

25 Image source: www.voxglobal.com

26 Gao & Li, 2010.

27 China National Development and Reform Commission, State Environmental Protection Agency, State Electricity Regulatory Commission, and the National Energy Bureau, 2007.

Of significance, the implementation protocols require installation of real-time emissions and heat-rate monitors at all thermal units and data sharing across agencies to establish and maintain an index of generating units for each provincial or regional grid.

Initially this dispatch method was implemented in five provinces. These provinces have employed varying approaches to address persistent technical and economic challenges, such as compensation for existing power purchase agreements, consideration of line losses and transmissions and distribution bottlenecks, and ensuring reliability and adequate ancillary capabilities. Systematic approaches to resolve these challenges will have to be finalized before the rule is set for national expansion under current plans. Although there are some nuances depending on local resource mix and grid characteristics – for example, in Sichuan where hydropower has displaced coal – the experience across the five initial provinces generally shows that more efficient coal units displace dirtier units, resulting in significant reductions in coal combustion. The average rate of coal consumption in Guangdong province, for instance, declined 3.4 percent from 323 to 312 grams per kWh in the first two years of implementation from 2007 to 2009.[28] Simulation studies of a selection of provinces have produced similar estimates of coal savings in the range of three percent,[29] which would have significant ramifications for CO_2, SO_2, NO_X, and particulate emissions nationwide. The dispatch rule also will have the effect of driving future investment toward cleaner and more efficient units, as is already being seen in the pilot provinces.

ii. The European Union – A Coordinated and Collaborative Approach to Product Market Transformation

The European Commission estimates that over 80 percent of all product-related environmental impacts are determined during the design phase of a product. The EU's Ecodesign Directive,[30] adopted in 2009 and the joint responsibility of DG for Enterprise and Industry (ENTR) and DG Energy (ENER),[31] attempts to reduce these impacts. It provides a framework defining consistent EU-wide rules for setting product-specific requirements (minimum standards or "Energy-Using Product [EuP] thresholds") on energy efficiency and further parameters in order to improve the lifecycle environmental performance of energy-related products. It thus prevents disparate national law on the environmental performance of these products from becoming obstacles to intra-EU trade.

The Directive covers 57 groups of EuPs, which use, generate, transfer, or measure energy (i.e., electricity and fuels), such as boilers, computers, televisions, transformers, industrial blowers, industrial furnaces, and so on. It also covers other energy related products that do not use energy but have an impact on energy use and can therefore contribute to saving energy, such as windows, insulation material, shower heads, taps, and the like.

To complement the Ecodesign Directive, the EU adopted an updated Energy Labeling Directive[32] in 2010. This directive requires all products to include an energy label (shown in Figure 2) and an information pack when offered for sale or hire, to provide consumers with information about the energy demand of the product. There are also binding requirements to incorporate energy efficiency classifications in advertisements and Delegated Acts to identify energy efficiency classifications below which Member States should not set incentives and/or procure products.

The Directive sets out a framework defining the rules for setting product-specific requirements on standard information regarding the product's consumption of energy and other resources. The labels have seven color-coded categories from A to G, and a review of the classifications is required when the top two categories are significantly "populated" and further room for improvement exists. The

28 Gao, 2010.

29 Mercados Energy Markets International, 2010.

30 Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products (recast) and COM (2006) 545 Action Plan for Energy Efficiency: Realizing the Potential.

31 Energy and transport policy, previously under DG TREN, was formally separated in 2010 with the formation of DG ENER and DG MOVE. In the same year DG CLIMA was created because the climate unit previously housed in DG ENV, responsible for environment policy, became too large. DG CLIMA is still located on the same physical site as DG ENV.

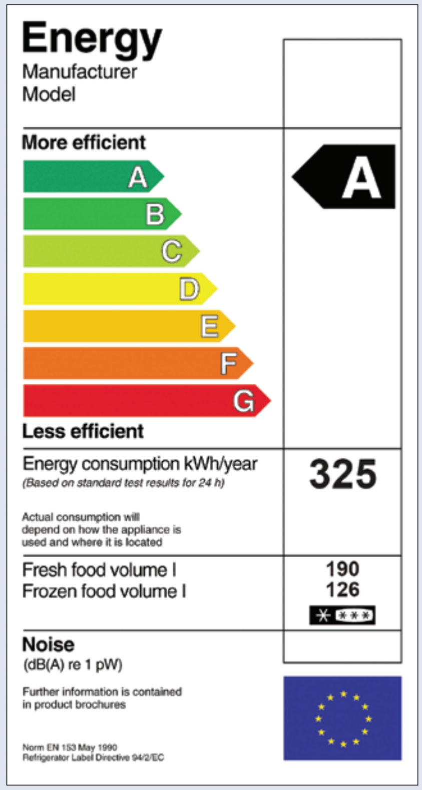
32 Directive 2010/30/EU on the indication by labeling and standard product information of the consumption of energy and other resources by energy-related products.

Directive largely applies to household products but can also apply to non-household products (e.g., motors), although it is less relevant for industrial products than consumer goods.

The combined effect of the Ecodesign and Labeling Directives ensures a dynamic improvement to product markets. The Ecodesign Directive pushes the market with binding minimum standards, and the Labeling Directive pulls the market by raising consumer awareness. The resulting "market transformation" process is illustrated in Figure 3, where the presence of the EuP threshold forces unit sales rightward by providing a minimum standard that removes inefficient EuPs (those to the left of the grey vertical line) from the market. Greater consumer awareness due to the Labeling Directive pushes sales further rightward (from the red line toward the green line), toward the purchase of more energy efficient products (i.e., from products with ratings of G, F, and E to products with ratings of A, B, C, and D).

Figure 2

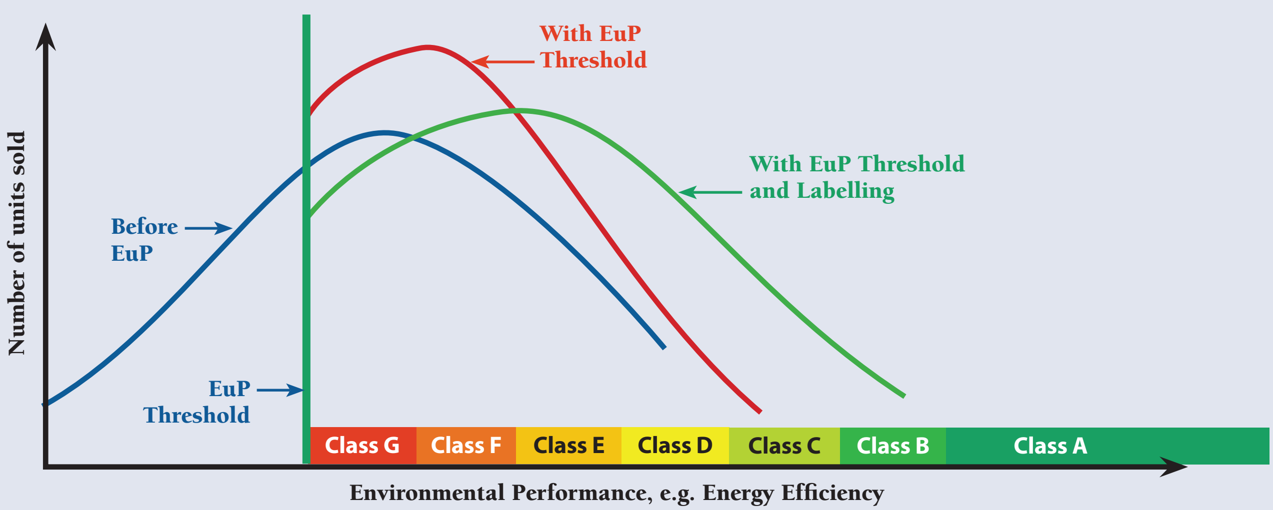
Sample Energy Label[33]



"Ordinary legislative procedure" at the European Commission requires inter-service consultation among DGs, but beyond this, working arrangements within the Commission are most often on an ad hoc, case-by-case basis. This leaves the Commission with flexibility to coordinate and collaborate as appropriate, but effective working arrangements will depend on factors such as leadership, management experience, attitude toward collaboration, and personal relationships between those involved.

Figure 3

Conceptual Illustration of Anticipated Market Transformation Due to EU Ecodesign and Energy Labeling Directives



Source: de Wilt, 2012

33 Retrieved on August 7, 2012, from http://www.elcfed.org/celma/presentations/files/2.Draft%20ecodesign%20&%20labelling%20legislation%20on%20lighting%20products_CELMA%20ELC%20LED%20Forum%20L+B%2018042012.pdf

Despite delays in the development of Implementing Measures for product categories, the Ecodesign and Labeling Directives provide good examples of effective collaboration between the Commission's DGs.

In the case of the Labeling Directive, led by DG TREN, an inter-service steering group (ISSG) was set up to oversee the impact assessment; it included participation from the following DGs: ENV (environment); SANCO (health and consumers); SJ (legal service); ENTR (enterprise); and ECFIN (economic and financial affairs). The first meeting discussed and agreed on the process and the contents of the impact assessment study and the Commission Staff Working Document (CSWD) for consultation of stakeholders. Three subsequent ISSG consultations took place before the Impact Assessment Report was submitted to the Impact Assessment Board.

Development of the Ecodesign Directive and coordination of its Implementing Measures, which set the standards for the various product groups, is led by DG ENTR, responsible for industry and trade. The process starts with the preparation of the Ecodesign Working Plan, which is discussed internally within the different Commission services (DGs) and with Member States and stakeholders. Working Plan 2012-2014 was published in January 2012.[34]

The Commission then follows a set procedure to develop the Implementing Measures, which includes:

- Preparatory studies: technical, environmental, and economic analysis of product groups with input from stakeholders around the world (carried out by consultants/contractors and published on dedicated websites);
- Consultation Forum: discuss suggestions for Ecodesign requirements;
- Impact assessment and inter-service (intra-DGs) consultation;
- World Trade Organization notification (as per the Technical Barrier to Trade Agreement);
- Vote in Regulatory Committee (EU Member States); and
- Scrutiny/Right of objection of the European Parliament and Council.

Development of the Implementing Measures for each product group identified in the Working Plan is led by the most appropriate DG with the strongest expertise in the area. The leading DG receives input from other DGs during the inter-service (intra-DG) consultation. Closer collaboration has sometimes been necessary, particularly when product groups are closely related. For instance, DG ENTR, leading on air conditioning and ventilation systems, has need to coordinate closely with DG ENER, leading on central cooling and central air heating. Such closer working has involved officials from DGs regularly participating in Consultation Forum meetings led by another DG, and some meetings have been co-chaired by colleagues of different DGs. These collaborative working arrangements have helped to ensure coherent product standards.

Although their enforcement has been somewhat inconsistent across member states, these coherent product standards have the potential to make a major contribution to reducing air pollution and GHGs.[35] By one estimate, the standards would amount to a 7-percent reduction in total fine particulate emissions across the EU-27 in 2020 and reduce black carbon and non-methane volatile organic compounds from small combustion sources by 25 percent and 50 percent, respectively, by 2020 below 2005 levels. Reductions in GHG emissions would be comparable to annual CO_2 reductions expected to result from the EU Emissions Trading Scheme by 2020 – with consequential large financial savings for EU energy consumers.[36] The Ecodesign Directive exemplifies how good energy policy is good environmental policy. However, the development and implementation of the Directives and their Implementing Measures will admittedly need to be improved and accelerated if this potential is to be realized, considering the EU's slow progress to date.[37]

34 For more information see: http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/product-groups/index_en.htm

35 IIASA. Emissions from households and other small combustion sources and their reduction potential. (2012, June). The study involves modeling of the potential contribution of Eco-Design Product Standards to EU air quality/pollution objectives. Potential emission reductions are found to be particularly large for PM2.5 and black carbon and can be even further increased if the Eco-Design standards are at the same time designed to affect energy efficiency standards.

36 Ecofys, for Natuur en Milieu, 2012.

37 Ibid.

iii. The United States – The New England Demand Response Initiative

The New England Demand Response Initiative (NEDRI) in 2002-2003 sought to develop a comprehensive and coordinated set of demand response programs for the New England regional power markets.[38] NEDRI was sponsored and supported by the US Department of Energy, the US EPA, the Independent System Operator of New England (ISO-NE), the public utility commissions of the six New England states acting through the New England Conference of Public Utility Commissioners (NECPUC), and the air directors of the six New England states and New Jersey acting through the Northeast States for Coordinated Air Use Management (NESCAUM).[39]

NEDRI began as a joint project of the Regulatory Assistance Project, which managed the technical consulting effort, and Raab Associates, Ltd., which managed the stakeholder process. Although initiated and largely driven by energy regulators, there was an extensive stakeholder process that included and drew heavily upon the expertise of regional air regulators. The goal was to bring together all of the pertinent players – the region's ISO, power marketers, utility and environmental regulators, and other stakeholders – to create workable market rules, public policies, and regulatory criteria that would encourage and support the involvement of customer-based demand response resources in New England's electricity markets. This was done with an eye firmly on the energy and environmental benefits and risks of deploying more demand response.[40]

A series of 19 stakeholder workshops, with 20 to 30 participants at each, were held between February 2002 and July 2003. During this period, stakeholders worked through many issues associated with demand response and its participation in markets in New England. Environmental issues and energy issues were given comprehensive and integrated treatment. The result of this work was the publication, in July 2003, of *Dimensions of Demand Response: Capturing Customer Based Resources in New England's Power Systems and Markets, Report and Recommendations of the New England Demand Response Initiative*.[41] A major conclusion of the report was that, "competition among electricity suppliers alone (without an active demand response) is not enough to create efficiently competitive electricity markets."[42] The report made 38 recommendations to support the comprehensive development of cost-effective demand response resources throughout the region.

As a result of this work, demand response and energy efficiency received significant attention in New England, gaining standing as real resources, with benefits for both energy and environmental regimes. Because of the thorough stakeholder process, there were many champions of NEDRI's message who then brought that message back to their respective energy and environment agencies. Policymakers, elected officials, energy regulators, and environmental regulators began to consider demand response and energy efficiency to be valid resources, with benefits for both energy and environmental regimes. And with this change in perspective, the region began to more fully exploit demand-side resources. For example, under a Federal Energy Regulatory Commission (FERC)-approved settlement in 2006, energy efficiency became a recognized, eligible resource to bid into ISO-New England's Forward Capacity Market (FCM).[43] After slowly building momentum over several years, energy efficiency is now playing a major role in ISO-NE's FCM, as shown in Figure 4.[44]

Every megawatt (MW) of energy efficiency cleared in the FCM represents a victory for the energy sector (because efficiency is the cheapest resource available) and a victory for the environment (because each forgone MW of energy generation represents forgone emissions and improved air quality).

NEDRI also pioneered an often-overlooked aspect of energy-environment integration by regulators: working together begets more working together. NEDRI's

38 See the NEDRI website at http://nedri.raabassociates.org/. Accessed on June 4, 2012.

39 NEDRI Executive Summary, 2002.

40 Among air quality regulators' interests, for example, were (1) concerns about industrial customers running diesel back-up generators to serve their load after being curtailed by demand response programs, and (2) characterizing the air quality gains that demand response could provide by avoiding operation of inefficient mid-merit and peaking plants during peak demand periods.

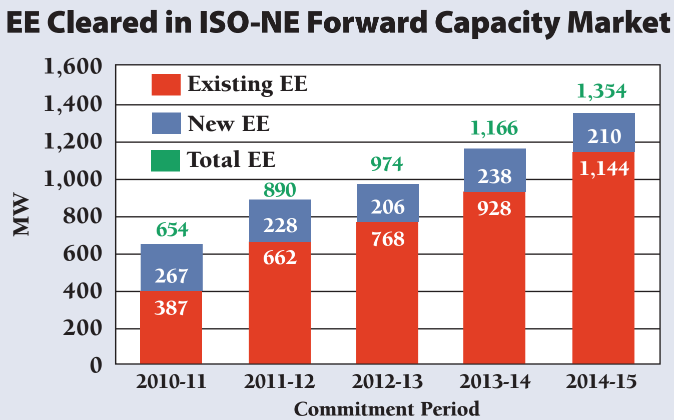
41 Cowart et al, 2003.

42 Ibid.

43 Peterson et al, 2012.

44 Winkler, 2011.

Figure 4



Cleared Capacity includes 8% Gross-Up. 2010-11 and 2011-12 also includes Reserve Margin – 14% and 16% respectively.

Source: Winkler, 2011

2003 efforts broke the trail for the Ozone Transport Commission's 2007 High Electric Demand Day (HEDD) work described later in this paper, which in turn helped enable joint energy-environment regulatory development of the RGGI to move forward. Effectively, a "virtuous cycle" driving more and better energy-environment regulatory collaboration was created.[45]

45 For all its success, NEDRI is also a good example of how tricky it can be integrating energy and environmental regulation. For example, distributed backup generators can be used on high demand days to reduce load drawing electricity off the grid, a good result for energy regulators trying to maintain reliability. However, backup generators are often powered by dirty, unregulated diesel motors that have deleterious air quality impacts, a result not desired by air regulators. This issue was a Gordian knot for NEDRI and remains so to this day.

4. How?

The preceding sections established why increased coordination of energy and environmental regulation is sorely needed and cited several examples of specific policies and practices that effectively integrate energy and environment policies. In this section, we describe principles and steps that regulators can take to adopt an integrated approach. We divide them into three categories:

- Organizational and institutional reforms that will enable better coordination of energy and environmental agencies;
- Economic principles that inherently integrate energy and environmental concerns; and
- Regulatory practices that invite cooperation between environmental and energy regulators.

A. Organizational and Institutional Reforms

There are a number of organizational and institutional reforms that can enhance cooperation between regulators from the environmental and energy fields. The issues highlighted below reflect an important and illustrative list, but not an exhaustive one. Several issues beyond the scope of this paper, such as national security and energy security, may also contribute to and benefit from greater energy-environmental collaboration.[46]

i. Legal Authority

The structure and function of government institutions often work to impede integrated decision-making across energy and environmental sectors. Clearly, little progress will be made if energy and environmental regulators do not talk to each other, if they choose to stay ignorant of important aspects of each other's area of responsibility, or if they are legally prohibited from considering each other's goals.

There is no simple formula for success. Solutions will vary as regulatory structures and practices vary across states, regions, and countries. Some may favor structural and relatively rigid solutions (e.g., changes in statutory authority) and others may favor comparatively informal, flexible, and readily altered solutions. One way or the other, the authority and mission of agencies should be broad enough to enable cross-disciplinary engagement.

Currently in the United States, explicit authorization for energy regulators to consider the environment is the exception rather than the rule. At the state level, for instance, the laws establishing most public utility commissions (PUCs) specify a duty to ensure safe and reliable utility services at just and reasonable rates. This broad public interest mandate typically is interpreted narrowly – that is, to exclude explicit environmental consideration – but it could almost always be interpreted to allow energy regulators to consider second-order effects like the probability of future environmental risks and their potential cost impacts.[47]

To assure the coordination of energy and environment, legislative reforms that expressly include environmental considerations in energy decisions – and vice versa – are the best solution. One good example comes from the US state of Colorado; its PUC's overarching obligation is to the "public interest," which it serves by ensuring "safe, reliable, and reasonably-priced services consistent with the economic, *environmental* and social values" of the state" [emphasis added].[48] The explicit inclusion in statute of

46 For more information on national security issues, see National Security and the Threat of Climate Change, CNA Analysis and Solutions, April 2007. Available at http://www.cna.org/reports/climate

47 See for example, Binz et al, 2012.

48 See http://www.dora.state.co.us/puc/about/AboutOversight.htm and http://www.dora.state.co.us/puc/about/AboutMission.htm.

"environmental values" in the mission of the Colorado PUC essentially makes energy and environmental integration expected and obligatory.

By comparison, the legal underpinnings of state environmental agencies are generally broad enough in scope to allow environmental regulators to consider energy-related policies. The obstacle to better integration of energy and environment here is generally a lack of awareness of how energy policy relates to environmental improvement. Most state air pollution regulatory programs in the United States operate under the authority of the federal Clean Air Act, delegated to the states by the EPA, which also provides funding for states to implement the Act's requirements. After decades of this practice, it is not uncommon for state air policy to be driven almost exclusively by the federal Clean Air Act.

Additionally, state air programs often enjoy broad statutory authority, typically due to their origin within public health agencies. New Hampshire's air pollution control laws are part of its public health statutes, for example, and declare it the policy of the state to:

> *"...achieve and maintain a reasonable degree of purity of the air … so as to promote the public health, welfare, and safety, prevent injury or detriment to human, plant, and animal life, physical property and other resources, foster the comfort and convenience of the people, promote the economic and social development of this state and to facilitate the enjoyment of the natural attractions of the state."*[49]

Arkansas is similar, declaring it state policy to "maintain such a reasonable degree of purity of the air … that the least possible injury should be done to human, plant, or animal life or to property and to maintain public enjoyment of the state's natural resources, consistent with the economic and industrial wellbeing of the state."[50] These provisions do not cite energy sources or issues explicitly, but certainly include them. Therefore, to pursue greater integration, environmental regulators in some states may simply need to utilize their existing authority more broadly than they have commonly done to date.

Legislatures, too, often recognize the importance of interagency collaboration, and some have taken explicit steps to avoid having agencies operate at cross-purposes. North Carolina's environmental policy act establishes an expectation of interagency cooperation[51] and directs that conflicts should go to the governor.[52] Georgia extends the expectation to the federal level, specifying that its Department of Natural Resources "establish and maintain perfect cooperation with any and every agency of the federal government interested in or dealing with the subject matter of the department."[53]

In a similar effort, the government of the United Kingdom undertook institutional restructuring in 2008 to better align jurisdictional authorities to address the challenge of climate change. It established the Department of Energy and Climate Change (DECC) to be responsible for energy and reducing GHG emissions. Previously it had been divided between the Department of Environment, Food and Rural Affairs (DEFRA) and BERR (Department for Business, Enterprise and Regulatory Reform). While energy teams across different ministries were brought together to address sustainable energy in a more coherent way, the responsibility for air and water pollution remains with a different department, DEFRA. A similar structural change took place within the European Commission; increased policy activity to address climate change, particularly concerning the EU Emissions Trading Scheme, led to the handover of responsibility for this policy area from Directorate General Environment (DG ENV) to a new Directorate General Climate Action (DG CLIMA). It is therefore ultimately up to the politicians, whether Ministers or Commissioners, to ensure coherent policy development between the different Departments or DGs.

Pollution and resource constraints in China have pushed environmental objectives to the top of the national agenda in the form of an all-encompassing government directive for "emission reductions and energy conservation." Like many of China's central-level policies, this directive exists outside the strict parameters of legal or statutory authority, yet it permeates all sectors of the economy and serves as the rationale for many of China's ambitious goals, including reducing energy intensity by 16 percent and carbon dioxide emissions by 17 percent below 2010 by 2015.

49 NH RSA 125-C:1

50 AR A.C.A. § 8-4-301

51 NC General Statutes § 113A-4

52 NC General Statutes § 113A-5

53 O.C.G.A. § 12-2-3

Under the "emission reductions and energy conservation" initiative, energy regulators have an environmental mandate and environmental regulators have an energy efficiency mandate. This has enabled many of China's policy innovations, such as the environmental dispatch practice and the rapid deployment of flue-gas desulfurization equipment.

The bottom line is that energy regulators need to have an explicit environmental mandate. This function need not and should not displace the responsibility of the environmental regulator, but the energy regulator must have the authority – and the obligation – to assist the government (and its environmental regulator) in meeting its public health, environmental, and climate responsibilities to citizens and in meeting these objectives with greatest reliability and at least cost. Environmental regulators need to have a similarly explicit mandate to integrate environmental policy decisions with energy system objectives. As it pursues protection of public health and welfare, the environmental regulator must have the authority and obligation to assist the government's energy regulator in securing reliable, affordable, clean energy solutions for its citizens.

With these two complementary mandates in place, energy and environmental policy integration becomes a cross-agency obligation, not simply a voluntary option. Aligning regulators' obligations diminishes agency conflicts over disparate goals and forces agencies to focus on identifying and implementing optimally integrated solutions.

In pursuing cross-disciplinary integration, key questions policymakers should ask about their jurisdictions include:

- Do energy regulators have the authority or mandate to consider, respond to, or address environmental impacts like pollutant emissions or water consumption in their decisions and orders?
- Do environmental regulators have the authority or mandate to consider, respond to, or address energy impacts like cost and reliability in their decisions and regulatory determinations?
- Do statutes require or encourage energy and environmental collaboration?
- Has the jurisdiction moved to eliminate major legal or institutional barriers to integrated consideration of regulatory and policy determinations by administrative and regulatory agencies on a regional, multijurisdictional basis?
- Do the two agencies have disparate or conflicting legal or administrative requirements regarding timing, deadlines, and so on?

We suspect that the answer to many of these questions is often "No." If so, public officials might do well to ponder why this is so. Why does a deeper level of cooperation not occur? Why is it necessary for executive leadership to step in in order to make cooperation more systemic and routine? Why is there insufficient willingness or expertise among staff to make cooperation possible? Why have staff levels not kept pace with mounting demands and increasingly complex issues, to such a point that officials from sister agencies have little time to interact? Until such fundamental questions can be addressed and resolved, structuring regular coordination between agencies and requiring multiagency interaction as necessary in regulatory orders can be an effective way to initiate interagency cooperation.

ii. Joint Regulatory Activity

Beyond legal or statutory mandates, energy and environmental agencies should build cross-agency pathways – both formal and informal – for cooperation and mutual understanding of each other's issues and objectives. Key questions for jurisdictions include:

- Are environmental regulators engaged in power sector decision-making and vice versa? For example, does the environmental agency include an office and/or staff dedicated to energy issues, and does the energy agency include an office and/or staff dedicated to environmental issues?[54]
- Are environmental and energy agencies both aware of and involved in practical issues associated with climate change (e.g., background science, expected impacts, sources of GHG emissions, opportunities to mitigate GHG emissions, ways to adapt to anticipated changes, and so on)?
- Are environmental and energy agencies aware of each other's compliance responsibilities (e.g., responsibilities of the provincial or state air agencies to the national level authorities, and the

54 This example is meant to address where cross-agency lines of authority intersect. There may also be a governor-level entity (e.g., a "cabinet") responsible for coordinating policy generally across these and other agencies.

responsibilities of state energy regulators to regional system operators and reliability organizations)?

- Are the multiple energy or environmental regulators in a region organized to consider factors of concern to the other (e.g., at the regional system operator level, or in responding to regional requirements such as Order 1000 of the US FERC)?[55]

In the United States, most state energy regulators operate under the authority of state law, whereas most state air pollution regulatory programs operate under the authority of the federal Clean Air Act, delegated to them by the EPA. As such, planning and regulatory requirements may be different. Coordinating the implementation of new rules or requirements to minimize cost and other impacts upon the regulated community is reason alone for energy and environmental regulators to communicate regularly.

Here again, Colorado is a leading state in operationalizing regulatory integration, as demonstrated by the adoption in 2010 of its Clean Air-Clean Jobs Act (CACJA). Designed to help Colorado achieve and maintain compliance with federal air quality standards, CACJA requires utilities with coal plants to submit a plan to reduce emissions and to meet reasonably foreseeable state and federal regulations. CACJA assigned to the Colorado PUC the authority to approve a utility plan, but allowed it to do so only if the state's environmental regulator "has determined that the plan is consistent with the current and anticipated requirements of the federal [Clean Air] Act."[56]

Another good example from the United States is the effort by the National Association of Regulatory Utility Commissioners (NARUC) to bring together regulators to discuss and address issues at the crossroads of energy and environment. To achieve this goal, NARUC formed an Energy Resources and the Environment Committee. The Committee focuses on energy and environment issues, such as energy efficiency, environmental protection, renewable and distributed resources, consumer protection, low-income weatherization and assistance, and public interest research and development. The Committee often provides a forum in which the state regulators, EPA officials, and FERC officials can discuss energy and environmental issues.

Coordinating energy and environmental policies can enhance enforcement. Enforcement of environmental regulations is an acknowledged weakness in many countries, and unlike many economic sectors, the power sector is largely centrally controlled. Grid systems require central dispatchers who must know at every moment which power plants are operating. Where power sector and environmental rules are integrated, system operators can readily serve as environmental monitors, enforcers, and collectors of pollution fees, and can do so within a market context. China's experience with flue gas desulfurization (FGD), detailed in Appendix A, demonstrates how powerfully effective this can be.

iii. Political Leadership

Even with regulatory and legal institutions in place, broad-based political leadership also may be needed to push forward integrated strategies for energy and environmental management. Key questions include:

- Is political leadership engaged as necessary to motivate agencies to collaborate (in the case of executive branch obstacles) and/or to reduce statutory constraints to integration (in the case of legislative obstacles)?
- Have government policies and actions focused on renewable energy development and deep implementation of energy efficiency?
- Has the government established and enforced renewable energy requirements (e.g., renewable portfolio standards, feed-in-tariffs, clean energy standards, and so on), energy efficiency standards, environmental quality limits, air/water pollution limits or caps, and/or GHG emission reduction targets with specific levels and timelines? Does it have policies in place or being developed to achieve these goals?
- Have specific changes to environmental regulation and/or power sector reform encouraged and/or required integration?
- Have policies reflecting integration been adopted (e.g., decoupling, preferential loading order, etc.)?

In many cases, effective policy initiatives would not have been possible without the determined backing and persistence of political leaders. In the EU, the leadership

55 For example, RGGI represents a case in which energy regulators in participating states are explicitly considering environmental issues and vice versa. Or, states in an RTO that includes environmental issues in its planning may have environmental regulators cooperating to the extent that they engage in the RTO planning process.

56 State of Colorado, Clean Air-Clean Jobs Act.

of Luxemburg Member of European Parliament Claude Turmes was critical to passing the Energy Efficiency Directive, a measure that is expected to substantially pave the way for the EU-wide goal to improve energy efficiency by 20 percent by 2020. President José Manuel Barroso of the European Commission likewise has shown strong leadership in developing a new comprehensive air quality management plan for the EU, ensuring that it reinforces concurrent energy and climate goals.[57] At the US state level, this was also the case with California's landmark Global Warming Solutions Act of 2006, Assembly Bill 32 (AB32), which was spearheaded by Governor Arnold Schwarzenegger, as well as the RGGI, an agreement led by the governors of the northeastern states to reduce regional GHG emissions. In 2009, Maryland Governor Martin O'Malley and the Maryland General Assembly passed the Greenhouse Gas Emission Reduction Act of 2009 requiring the state to reduce GHG emissions 25 percent from 2006 levels by 2020 and developing the policies to achieve this goal.

B. Economic Principles

Political feasibility is often determined by economic factors. In a sector like the power sector, in which negative externalities are substantial, how resource options are evaluated can have an equally substantial effect on the ultimate scale of those externalities and how they are borne across society. To facilitate a holistic approach to the management of environmental and energy resources, economic analyses should strive to consider resource decisions comprehensively and to minimize the total cost to society.

i. Comprehensiveness

Questions for regulators and policymakers to ask to ensure economic considerations are sufficiently comprehensive in scope include:

- Is a comprehensive analysis of resource options and issues undertaken when new power plants or major retrofits are taken under review?
- Is Integrated Resource Planning (IRP) required in the jurisdiction?
- Are all environmental compliance obligations, both short- and long-term, taken into account?[58]
- Do regulatory strategies for air quality management consider measures upwind and downwind of the pollution source?
- Are environmental characteristics reflected in fleet dispatch?
- Does transmission and distribution planning require environmental issues and non-transmission alternatives be taken into account?[59]
- Have regulators reached consensus on what comprises an acceptable baseline (i.e., what will happen absent coordinated action)?

Full cost accounting refers to an accounting methodology that incorporates economic, social, and environmental costs, both direct and indirect. For the power sector, environmental externalities are primarily manifested in damages to public health and agricultural productivity. What we are calling a "comprehensive analysis" takes full cost accounting a step further and requires that the boundaries of the analysis be drawn broadly enough to identify optimal solutions for delivering both energy and environmental services. A comprehensive economic analysis of electricity resources, for example, will include consideration of not just supply-side but also demand-side resources, such as energy efficiency improvements and demand-response; not just generation, but also transmission and distribution resources; and not just today's power sector, but also the expected changes within the industry, like deployment of smart grid infrastructure and constraints on carbon emissions.[60]

57 European Commission, 2011.

58 One such approach is called "Integrated Environmental Compliance Planning." This is a process used to inform a system-wide perspective for regulatory and investment determinations across near- and long-term, pre-existing and anticipated, environmental compliance obligations. See Testimony before the Oklahoma Corporation Commission, on behalf of Sierra Club, on the topic of fuel-source related issues, July 18, 2011.

59 For more on the benefits of demand-side resources for transmission and distribution systems, see Neme & Sedano, 2012.

60 In the U.S., FERC recently opened the door to greater comprehensiveness in regional transmission planning through its Order 1000 issued on May 17, 2012. This order requires regional transmission organizations to incorporate state input with respect to public policy issues, such as renewable energy or energy efficiency obligations.

Controlling multiple pollutants – NO_X, SO_2, particulate matter, and mercury emissions, for example – can carry a high cost that substantially affects the bottom line of a fossil fuel plant. Each piece of pollution control equipment can add hundreds of millions of dollars in capital investment alone. To evaluate compliance costs on a pollutant-by-pollutant basis fails to capture the true cost of plant operations. Costs associated with meeting existing regulations, as well as future potential costs associated with air, water, and solid waste requirements, therefore should be included in a comprehensive analysis of resource or retrofit costs during the project deliberation process.[61] To effectively identify least-cost resource options, these potential compliance costs should be compared with all generation and non-generation alternatives.

Utility regulations and system operations explicitly should require consideration of environmental costs, even if they are not commonly found on financial statements. Whether society pays these costs in utility rates, taxes, the cost of a product or service outside the energy sector, or through degraded health and quality of life is of little importance because "ratepayers," "taxpayers," "consumers," "patients," and "residents" are, in reality, the same people. If we know an impact is not negligible, then any regulatory process that assigns zero as its cost is surely inaccurate. At the same time, in the absence of accurate cost information, it is important not to burden ratepayers unreasonably.

Conversely, many clean energy resources – especially distributed generation, combined heat and power, energy efficiency, demand response, and photovoltaic panels – deliver auxiliary benefits across a system in addition to providing energy services to meet demand. These benefits may include: eased constraints on transmission and distribution networks allowing deferment of investment in additional infrastructure; lower emissions of ozone precursors at peak times during high-energy demand days; reduced electric system losses; reduced energy price volatility; and potentially even water-related benefits.[62] These and other benefits may or may not be readily monetized, but they certainly reflect real, non-zero benefits that should be incorporated in energy system planning.

ii. Cost-Effectiveness

A "comprehensive view" would also account for costs across all sectors. Whether through market-based instruments or conventional regulation, policy intervention should be designed to minimize the total cost to society as a whole, including direct and indirect costs and benefits to stakeholders. Questions for regulators include:

- Do compliance costs associated with environmental regulations approximate the costs associated with environmental damages?
- Are environmental externalities adequately reflected in energy prices and decision-making?
- Do environmental and energy markets account for the environmental attributes of resource options?
- Are energy market rules structured to produce results consistent with environmental objectives and compliance obligations? And vice versa: are environmental rules structured to produce results consistent with energy sector objectives?
- Are environmental regulations adequately designed to reduce total costs, that is, compliance costs, in addition to environmental damages?
- Which type or style of cost-effectiveness tools are used, and are they adequate to the needs and concerns of both groups of regulators?

In theory, economic efficiency is determined by the point at which the cost of reducing one additional ton of pollution equates to the benefit to public health and welfare of reducing that additional amount of pollution. While the conventional purview of power sector regulators is to keep direct costs – and thus customer rates – low, this focus can run counter to finding the least expensive solutions for society across all sectors. If in fact economic efficiency were the goal, many regulations would be stringent enough to elicit substantially higher compliance costs in the power sector. One example of this would be in the area of coal-fired power generation, where environmental externalities due to air emissions are estimated at levels that exceed the value-added by that industry.[63]

Wherever possible, market-based solutions should be implemented to reduce costs and improve economic efficiency. Markets in and of themselves are not a goal, however, but rather a means unto an end. It is the design

61 Lazar & Farnsworth, 2011.

62 Navigant Consulting, Inc, 2006.

63 Gross environmental damages due to air pollution in the coal-fired power industry are estimated to exceed the economic value-added by more than 2:1. Muller et al, 2011.

and rules of a market that ensure it delivers the desired results – this is especially so with regard to environmental goods.

In some cases, due to limitations in our economic and scientific understanding of pollution, market-based approaches may not, in fact, be optimal. To reduce the costs of reaching a regional cap on SO_2 emissions, for example, the Acid Rain Program allowed undifferentiated trading across the entire eastern United States, although pollution damages were not homogenous across the region. The program's use of allowance trading succeeded in reducing compliance costs for firms far below expected levels, but relative to a more prescriptive approach, it did not necessarily reduce costs associated with the health impacts of SO_2 pollution, most notably those associated with fine particulate matter in densely populated areas. In fact, some studies indicate that if local effects are considered, direct regulation may be a more cost-effective solution for reducing health impacts.[64] Today modern integrated assessment models, which combine pollution exposure rates and health data with atmospheric dispersion models, allow greater precision in estimating pollution damages. Consequently markets – whether for pollution allowance trading or electricity dispatch[65] – can aspire to more duly reflect these costs. Where pollutant interactions and their direct and indirect effects on human wellbeing are highly uncertain, however, quantifying and internalizing environmental externalities into market prices may be problematic. For this reason, prescriptive standards and requirements, which approximate environmental externalities, can also be very effective solutions.

One attribute that makes market-based tools attractive is the flexibility they offer regulated entities in achieving compliance. A firm can evaluate for itself the best way to comply, whether by upgrading control equipment, shifting to cleaner fuel, buying allowances, investing in offsets, or banking allowances for future years, thereby reducing costs and preserving freedom of choice. Flexibility, however, is a design aspect that can be built into both market-based and prescriptive regulations alike, and while it is generally proven to reduce compliance costs, greater regulatory flexibility does not always minimize pollution damages.[66] The degree of flexibility offered in markets and other mechanisms therefore should not compromise health-based environmental objectives.

C. Regulatory Principles

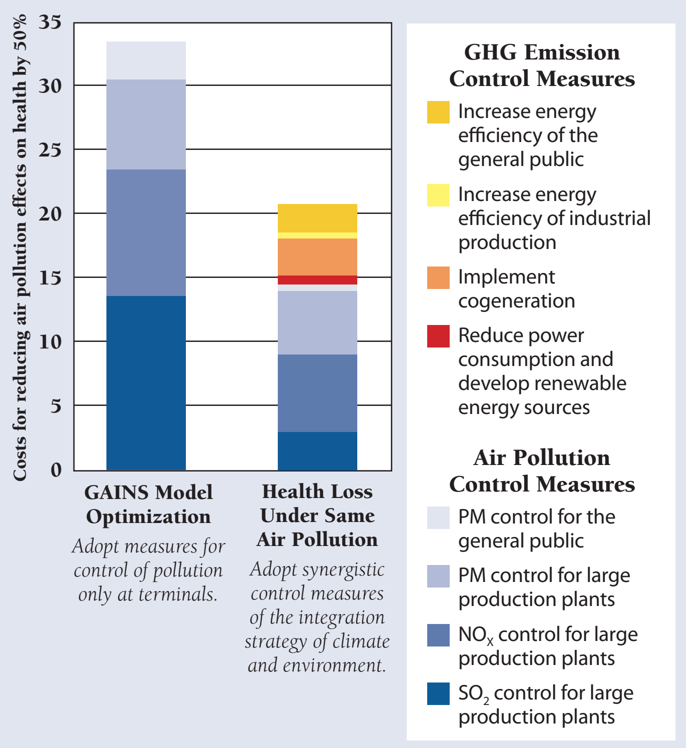
In addition to institutional and economic cornerstones, there are a number of guiding regulatory principles that can help to achieve shared objectives in energy and environmental management. Several of these principles are enumerated below.

i. Multipollutant Approaches

A multipollutant approach, as depicted in Figure 5, takes into account a full range of conventional, toxic, and climate-forcing pollutants at the same time. This contrasts

Figure 5

Synergistic Effects of Multipollutant Planning[67]



64 Muller & Mendelsohn, 2009.

65 "Full-cost dispatch" was first proposed in the early 1990s to reduce total system costs through true economic dispatch of electric resources. This approach would organize system operations to reflect fuel costs in addition to environmental externalities, specifically those pertaining to conventional air pollution emissions. Bernow et al, 1991.

66 Bennear & Coglianese, 2012.

67 Based upon Bollen et al, 2009.

with the more common pollutant-by-pollutant approach, which first addresses one pollutant, then another, and so on. Multipollutant approaches can help identify comprehensive, upstream interventions that achieve lower cost solutions across the economy. In the power sector, multipollutant regulations might simultaneously consider SO_2, NO_X, PM, mercury, CO_2, and other pollutants to produce more cost-effective strategies for emissions control, including improved end-use and thermal energy efficiency. This is because the emission limits can be set with an appreciation of how controlling one pollutant affects the production of others, thereby giving generators greater flexibility in achieving compliance. In combination with other policies – such as revenue decoupling – this approach can also encourage investments in energy efficiency and innovative technologies, such as integrated gasification combined cycle, which may have higher initial capital costs offset by lower emissions control costs.

ii. Output-Based Emission Standards

Wherever possible, output-based emission standards should be employed. Historically, power plant emissions in the United States have been regulated on the basis of fuel-input – for example, pounds of emissions per million British Thermal Units of coal combusted – an approach that evolved from a tradition of regulating emissions according to the industrial process (e.g., asphalt manufacturing, chemical refining, cement production, coal-fired power generation, and so forth). Input-based regulations establish emission standards for specific production processes or fuels, but without regard for operational efficiency. In contrast, output-based standards relate emissions to productive output, setting limits based on the amount of emissions produced per unit of useful output. In the electric power sector, output-based approaches typically limit the pounds of pollution emitted per kWh of electricity produced. In terms of societal benefit, this is preferable to a heat-input approach, because a generator with twice the heat rate of another would emit twice as much pollution to produce the same kWh, yet both would comply with the standard.

Output-based emission standards align the interests of emitters and investors with those of the public: all would seek production of the greatest useful output at the lowest level of pollution. As such, output-based approaches offer a number of benefits over traditional methods based on heat rate or other inputs. They drive increased investment into more efficient production techniques and processes, which creates environmental benefits for society at large by reducing pollution, and economic benefits for the regulated entities by improving production efficiency. Output-based standards also allow for easier comparison of the emissions performance of different technologies, because a clear, common unit reflecting the desired output can be utilized (e.g., lb/MWh) rather than a variety of input-based units (e.g., lb/MMBtu, lb/Mcf), which are confounded by the need for additional information like heat rates.[68] Finally, output-based emission standards make it easier for regulated entities to utilize energy efficiency measures as a compliance option.[69]

iii. "Clean First"[70]

Power sector regulators and stakeholders typically balance multiple and sometimes competing priorities. In many parts of the world, objectives such as "safe, adequate, reliable service at reasonable prices" and principles such as prohibitions on "undue discrimination" are commonplace. "Clean First" is an overarching regulatory principle for aligning power sector policies and practices with climate and environmental policies by adding environmental sustainability to the mandate of power sector regulators. Clean resources, those that minimize air and water pollution, land-use impacts, and toxic waste, should get every reasonable preference – whether it be in siting new transmission, access to the transmission system, cost allocation, or in grid operations generally – over resources that have greater environmental impact. This is not only about preference; it is about paying attention to and implementing market rules and planning practices that engender the unfettered growth of clean resources, consistent with sound reliability.

68 See ACEEE, 2012.

69 In this regard, China is a good example, having successfully incorporated lessons learned in the U.S. and elsewhere, employing output-based allocation methodologies for its SO_2 targets, and output-based energy efficiency manufacturing standards for key industries.

70 Regulatory Assistance Project, 2010.

iv. Priority Access

The development and use of more renewable generation is one of the better ways to integrate the needs and goals of environment and energy. Thus, energy policies that foster the adoption of more renewables should be encouraged. The European Renewables Directive is an excellent example of this kind of regulatory construct. The Directive requires Member States to provide guaranteed or priority access to the electricity grid for renewable resources. For Germany and some other EU states, the success of extending renewables is mainly based in this priority access (beside the feed-in tariff) with standard contracts. Before this Directive had been implemented, complicated and individual access rules made it extremely difficult to connect distributed renewables to the grid. Priority access also can be implemented effectively through regulations prescribing loading order to meet grid demand (e.g., all available energy efficiency first, then renewables, then gas, and so on).

v. Environmental Disclosure

Environmental costs are often indirect and thus not reflected in energy prices, making access to environmental information all the more important in order to allow consumers to make educated decisions that reflect their preferences in the market place. Public disclosure of environmental characteristics of electricity supply, such as a consumer labeling program that conveys to customers the pollution content of the power consumed, would be a step in the right direction. In liberalized markets, environmental disclosure would enable competition among utilities for cleaner supply offerings. In the United States, emission tracking systems in the New England and PJM power pools have been implemented to support environmental disclosure. Green pricing, a service now provided widely by utility companies around the world, affords customers the option to support investment in cleaner energy resources through a premium on their utility rates. The obligatory disclosure of environmental characteristics could be implemented as an extension to green pricing programs.

Figure 6

Sample Environmental Disclosure Labels[71]

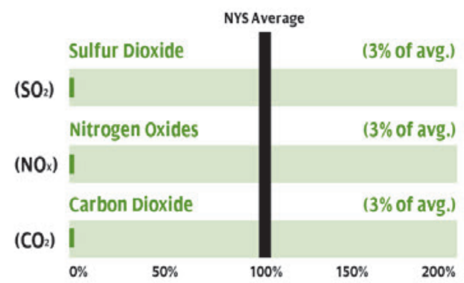
Fuel Sources Used to Generate Your Electricity

- January 2009 through December 2009
- Actual total may vary slightly from 100% due to rounding

Biomass	Less than 1%
Coal	Less than 1%
Hydroelectric	14%
Natural Gas	Less than 1%
Nuclear	82%
Oil	Less than 1%
Solar	Less than 1%
Solid Waste	Less than 1%
Wind	2%
Total	**100%**

Air Emissions Relative to the New York State Average

- January 2009 through December 2009



vi. Better Synchronized Planning Horizons

Long- and short-term planning horizons for energy and environmental sectors should be more strategically aligned to minimize costs and pollution damages. Air pollution and energy security are often considered to be near-term problems, whereas climate change is assumed to be a more distant challenge. Likewise energy and climate modeling efforts often explore longer-run scenarios, while air and water resource analyses do not. Efforts should be coordinated and planning horizons and regulatory guidelines should be set far enough into the future to provide greater certainty for investment decisions and to help achieve energy and environmental goals at least cost over the long run.

vii. Integrated Management Tools

To take advantage of the synergistic solutions between energy security, air and water resource supplies, and climate change mitigation, a suite of decision-making support tools will be needed to enable regulators and policymakers to readily weigh their options in light of competing objectives. Some of these tools, like the IRP practice used in regulated electricity environments, may exist in part already, and may only require modifications to accommodate additional public policy priorities. Other tools will have to be developed, whether in the area of integrated assessment modeling, multipollutant cost-curves, or streamlined protocols for avoided emissions quantification and verification.

71 Retrieved from www.rge.com on October 26, 2012.

5. Decision Support Tools

Just as a legacy of institutional and regulatory practices can inhibit greater coordination between the energy and environmental sectors, the tools that regulators rely on can reinforce old habits. For energy and environmental regulators to more effectively work in a mutually supportive manner, they will need decision-making tools and procedures that reflect a broader set of priorities. In some cases, existing conventions can be updated and adapted, in other cases, new modeling tools, planning techniques, and open lines of communication will be required to better facilitate comprehensive analysis and resource management.[72]

One important opportunity for cross-sector collaboration is in the area of developing standard, streamlined methodologies for quantifying the fossil fuel emissions avoided by energy efficiency and renewable energy projects. In order for the multipollutant air quality benefits of clean energy resources to be valued, whether by the market or government regulators, their avoided emissions must be quantified. But marginal emissions rates for many pollutants (e.g., SO_2, NO_X, mercury) cannot be readily determined on a generic basis. This is because installed pollution control equipment, the removal efficiency of that equipment, boiler design, and fuel quality at fossil fuel plants can differ substantially across regions, across similar plant types, and even across hours of operation at a single plant. Estimating avoided emissions of CO_2 can be a more straightforward function of fuel type and combustion efficiency, but large variations can still occur depending on the quantification method used.Just as a legacy of institutional and regulatory practices can inhibit greater coordination between the energy and environmental sectors, the tools that regulators rely on can reinforce old habits. For energy and environmental regulators to more effectively work in a mutually supportive manner, they will need decision-making tools and procedures that reflect a broader set of priorities. In some cases, existing conventions can be updated and adapted, in other cases, new modeling tools, planning techniques, and open lines of communication will be required to better facilitate comprehensive analysis and resource management.

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72 One good illustration of this need in the U.S. is recently adopted FERC Order 1000, which requires transmission planners to include input from new stakeholders and to include new public policy considerations in their planning deliberations.

73 Jacobson & High, 2010.

74 In this sense, each energy efficiency measure or program has its own supply-displacement profile. In large volume, these measures can aggregate to form the equivalent of a large power plant, free of attendant emissions and environmental consequences.

avoided emissions benefits of clean-energy resources, without undue administrative burden, thus poses a challenge. Progress is being made in this direction, however; various efforts are underway that assemble a variety of efficiency measures that collectively echo the characteristics of a supply resource like a power plant. Other efforts are underway that would identify available renewable generation supply resources and seek to control (to the extent possible) load dynamically, leaving the remaining "residual load" as that needing to be met through fossil-fired generation.[75]

System operators can help project developers and regulators quantify these and other benefits by regularly making available reports of marginal plant operations and associated emissions rates.[76] In the United States, ISO-NE has done this annually since 1994 to support NO_X offsets for demand-side management programs.[77] It now integrates hourly emissions data recorded in situ by continuous emissions monitoring systems at power plants with its own hourly dispatch data to develop a schedule of specified on- and off-peak and seasonal emission factors. This is a simple practice that could be adopted widely by system operators to facilitate estimation of avoided emissions for energy efficiency and renewable energy projects.

Impact assessment protocols that evaluate the effects of policy initiatives across sectors, like the EU impact assessments discussed earlier, are a good starting point for integrating energy and environmental priorities into decision-making. IRP also represents a similar kind of planning convention. IRP is a least-cost planning method traditionally used by integrated utilities under government regulation to help determine the best way to meet projected long-run consumer demand for electricity services given a multiplicity of objectives, whether grid reliability, economic, or social, in the midst of uncertainty and risk. In a deregulated utility industry structure, IRP analysis can still be an effective way to guide investment either on a jurisdictional level or the level of a regional transmission operator.

> Political reality often accompanies regulatory decision making, of course. When energy regulators avoid environmental issues and the impacts that their decisions give rise to, they are less likely to face any backlash due to corresponding rate increases. Conversely, if utility regulators choose to consider environmental matters, they help take the pressure off of environmental regulators from appearing to be driving up costs. There is a natural tendency to shift responsibility, even if it results in a disservice to the public good. Accordingly, it is important that practices be codified for the benefit first of the public interest, not for the convenience of one administrative agency or another.

An IRP study typically addresses energy demand over a 10- to 30-year time period and, of significance, requires that supply- and demand-side resources be compared side by side through cost-benefit analysis to identify the least expensive options for meeting future demand. Power generation has a distinct and wide-ranging effect on the environment. Although environmental costs and management goals can be, and sometimes are to an extent, incorporated into IRP studies, their results would be consistently improved if the analysis comprehensively reflected the full range of substantial, known externalities; namely, the externalities associated with GHG emissions, conventional air pollutants, and water and land resource consumption.

Intuitively such a tool for optimizing policy priorities would also serve well the purposes of environmental regulators, yet they typically lack any comparable planning practice or convention. In the United States, the federal State Implementation Plan (SIP) process requires states to develop pollution management plans to bring local air quality into compliance with NAAQS.[78] China has recently

75 For more information, see Dupuy, 2010 and Hogan & Gottstein, 2012.

76 Emissions profiles calculated in this manner can either represent the emissions characteristics of a tranche of load, say 10 MW displaced across all hours, or, if demand-side resource-specific, such emissions profiles could be differentiated hourly across weekday and weekend seasonal patterns.

77 Independent System Operator of New England, Emissions Reports. Available online at http://www.iso-ne.com/genrtion_resrcs/reports/emission/index.html

78 However, in areas that are in or have achieved attainment with NAAQS, SIPS are not required.

instituted a similar five-year planning requirement for key regions and heavily polluted cities as part of its 12th Five Year Plan. Yet these activities tend to be narrowly focused, both in terms of time horizons and goals, and thus generally fail to take into account greater implications for environmental quality and social costs farther out into the future.

Alternatively, regulators could develop long-term least-cost planning for air quality to evaluate the cost-effectiveness of both post- and pre-combustion abatement options across multiple pollutants. This might include cost-curves for a full range of air pollution control measures to evaluate – for example, boiler efficiency upgrades, renewable energy, and end-use energy efficiency as zero-emission control options that displace fossil fuels – and compare them alongside conventional mitigation technologies applied at the tailpipe or smokestack, like particulate filters (bag houses) and FGD units. With a 10- to 15-year horizon, such analysis would enhance coordination between air quality and energy planning and help ascertain options to reduce total costs, both regulatory and capital infrastructure costs, across a system, while meeting all the goals of utility and environmental regulators.

Longer-horizon scenario modeling out to 2030 or 2050 is commonly used to analyze energy demand trajectories, but these kinds of studies are rare for environmental resources. In many cases, there may not be a need to duplicate efforts. Power system operators, for example, routinely undertake dispatch modeling efforts to assess how changing factors like fuel prices, newly introduced government standards or incentives, and investment trends will affect grid operations and reliability years into the future. These efforts could be expanded to include technical teams from air quality and climate agencies to better assess the environmental attributes of grid operations under the various scenarios.

In addition to focusing on these areas for greater regulatory cooperation and integration in the modeling of future planning scenarios for policy purposes, policymakers now have improved tools available, because modeling itself has evolved significantly. Modern modeling approaches appear ready to address – and increasingly, to optimize – the complex web of energy, environmental, social, technical, and economic interrelationships. A fuller discussion of modeling approaches appears in Appendix B.

6. Key Recommendations

At bottom, solving for environmental quality is as important as solving for reliability and least cost in power system operations and planning. Omitting environmental considerations from this equation leaves utilities, investors, and whole societies vulnerable to unfavorable surprises as unexpected environmental events arise or compensatory environmental regulations are adopted with their associated compliance costs and system effects. Furthermore, segregation of environmental and energy issues inevitably leads them to be pitted against each other to some degree, which is wasteful and contrary to the interest of the public; it requires both.

To summarize the detailed suggestions found earlier in this paper, the following actions are essential for effectively integrating energy and environmental planning and decision-making:

- Energy regulators need to have an explicit environmental mandate. This function need not and should not displace the responsibility of the environmental regulator, but the energy regulator must have the authority and the obligation to assist the government (and its environmental regulator) in meeting its public health, environmental, and climate responsibilities to citizens, while meeting these objectives in a manner that is consistent with electricity sector objectives for reliability and cost. Environmental regulators similarly need to have an explicit mandate to integrate environmental policy decisions with energy system objectives. As it pursues protection of public health and welfare, the environmental regulator must have the authority and obligation to assist the government's energy regulator in securing reliable, affordable, clean energy solutions for its citizens. With these two complementary mandates in place, energy and environmental policy integration becomes a cross-agency obligation, not simply a voluntary option. Aligning regulators' goals diminishes agency conflicts over disparate interests and forces agencies to focus on identifying and implementing optimal integrated solutions in the public interest.

- In order to facilitate power system planning that integrates and is responsive to environmental and public health concerns, environmental agencies should undertake comprehensive, multipollutant approaches to regulation, inclusive of GHGs. Furthermore, emissions limits and other environmental standards should be uniform, stable, predictable, and output-based. Implementation of emission limits and environmental standards should incorporate regular, predictable, incremental changes in stringency to meet environmental and public health goals. Some have suggested that comprehensive environmental approaches can impose undue hardship on regulated entities. Predictable, comprehensive regulatory paths can provide far greater certainty than unpredictable, piecemeal approaches, however, reducing not only investment and regulatory risk but reliability concerns and associated costs as well.

- Practices favoring electric generation based on superior environmental performance and efficiency do not comprise "undue discrimination." On the contrary, they can support achievement of society's public health and environmental goals. Accordingly, such discrimination (e.g., in dispatching supply resources) should be expressly authorized as a necessary element of energy-environment policy integration, particularly in market economies with un-priced externalities. Where externalities can be demonstrated clearly and convincingly, policymakers should assign values to them. Externalities can be difficult to quantify rigorously and policymakers' judgment must sometimes prevail, but assigning them a value of zero is assuredly the wrong course; this practice implicitly disregards their existence and genuine impact on public wellbeing.

- In many jurisdictions, the integration of energy and environmental decision-making would be served well if environmental regulators considered and adopted forward-looking planning approaches analogous to those employed by their energy counterparts. Whether in individual utility IRP or grid operators' overall capacity and transmission planning for reliability purposes, it is typical for energy regulators to look ahead, essentially asking, "What level of reliability do we want to ensure and by when?" By contrast, it is not uncommon for environmental regulators to operate in a primarily responsive manner, addressing air quality, water supply, or contamination only after health standards are exceeded or when violations are imminent. Imagine, for example, if air quality officials asked and proactively addressed questions like, "How clean do we want our air to be and by when?" rather than, "How can we reduce emissions enough to attain national air quality standards?" Common, forward-looking regulatory approaches would also facilitate the use of planning and modeling tools. Indeed, effective integration of energy and environmental decision-making hinges on the use of common tools and integrated analytical methodologies. The EU's integrated modeling by the International Institute for Applied Systems Analysis (IIASA) reflects a positive step in this direction, and IRP could readily incorporate emissions and water impacts and constraints.

- Paradoxically, in many situations the least-cost solutions to environmental compliance obligations may not lie under the control of environmental regulators. Rather, they may be within the control of the energy regulator. For this reason alone, cooperation between the energy and environmental regulators is in the public interest.

- Energy regulators should take the initiative in developing greater integration of energy and environmental decision-making, because they often enjoy comparatively greater flexibility and opportunity:
  - In many jurisdictions, energy regulators enjoy substantially broader statutory authority and/or less federal oversight than environmental agencies.
  - Energy regulators are arguably better positioned internally, in that their responsibilities are already more integrated. With some exceptions in organized markets, energy regulators' purview typically includes capacity, generation, transmission, distribution, and often energy efficiency and renewable energy programs or obligations. In addition, energy regulators often oversee related functions that can have environmental impacts, including siting, service levels, financing, policies and tariffs, grid operations (including emergency conditions), and so forth. By contrast, environmental regulators often manage individual pollutants under separate and distinct regulatory programs (e.g., acid precipitation, ozone, toxic contaminants, GHGs, and the like), and environmental programs for different media (i.e., air, water, waste, land use) are rarely integrated.
  - Energy regulators (and utilities) have a stronger tradition of long-term planning and more experience in the use of planning tools and analyses, from regional dispatch modeling to comprehensive continental efforts, like the EU 2050 Roadmap.[79]

- Energy and environmental regulators must remain mindful of the need to address electricity demand generally and peak demand specifically. Both are important. Satisfaction of overall electrical demand determines absolute emissions, which is particularly important concerning long-lived, global pollutants like GHGs and persistent bio-accumulative toxic compounds like mercury. However, high electric demand days typically create disproportionate emissions, as even the dirtiest supply resources are pressed into service. Not surprisingly, policy responses correspondingly can differ. Demand response activities are typically designed to meet peak load conditions, but poorly planned demand response actions actually can lead to increased emissions (e.g., as when load is curtailed from the grid but then met through on-site generation using uncontrolled diesel engines). Energy efficiency activities typically reduce overall electrical load but may or may not assist materially in addressing peak demand conditions or high electric demand day emissions, depending on the efficiency programs deployed and their resource profile.

- Operational understanding of both energy issues and environmental and public health concerns appears to be evolving toward larger and larger scales. Generation

79 European Climate Foundation, 2010.

fuels and efficiency opportunities and technologies are now largely global commodities and products, and electric transmission and distribution is evolving from smaller to larger planning and control areas to better address reliability and incorporate variable generation. Environmental management is evolving similarly, from local air quality concerns (e.g., metropolitan nonattainment areas), to regional and interregional pollution transport issues, to climate change and other global concerns. Water issues are moving similarly from local quantity and quality concerns to national and multinational adequacy, allocation, and quality concerns. This suggests that effective efforts to integrate energy and environmental decisions should ultimately include regional-scale considerations and collaboration.

7. Conclusion

Thomas Jefferson opined that, "The happiness and prosperity of our citizens ... is the only legitimate object of government and the first duty of governors."[80] If one accepts this overarching characterization, regulators – as instruments of government – are compelled to operate in the overall public interest. In fulfilling their direct responsibilities for reliability and affordability, energy regulators must recognize that these are pieces of, but not the whole of, the public interest. Similarly, in fulfilling their obligation to protect public health and environmental quality, environmental regulators must recognize that these too are pieces of, but not the whole of, the public interest. This paper identifies, illustrates, and calls for concerted, proactive integration of energy and environmental decision-making, not only because energy and environmental regulators have a common obligation to the public and must not make each other's task more difficult, but because the incredible opportunities for energy-environmental integration today – and the daunting challenges that we face tomorrow – together make integration a compelling duty in the name of public well-being and prosperity.

80 Thomas Jefferson to Thaddeus Kosciusko, 1811.

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Appendix A

Energy and environment issues interrelate, and an operational awareness of this interrelationship is essential to effective regulatory execution in both fields. Regulators from energy and environmental disciplines demonstrably need to work together actively to find new and better ways to integrate their responsibilities. Fortunately regulators from both disciplines in different jurisdictions across the globe have, at times, achieved just this kind of integration. There have been good outcomes from their interactions and bad outcomes from their lack of interaction.

Because there are no silver bullets, solutions will reflect the idiosyncrasies of regulatory, political, and legal traditions across jurisdictions. Examples of success stories are especially important to illustrate how effective integration of energy and environmental regulation can be achieved. This section reviews a handful of examples from around the world. This review is illustrative, not exhaustive. It highlights four examples of how and where such interactions have happened, focuses attention on where the interaction has generated positive results, and notes glitches in the process. The four examples include:

1. China's approach to environmental and energy integration;
2. The Ozone Transport Commission's High Electric Demand Day (HEDD) Project;
3. The Regional Greenhouse Gas Initiative (RGGI); and
4. The Energy and Water Nexus.

A. China's Approach to Integration

Over the last decade, China has found itself facing the unprecedented challenge of meeting double-digit annual growth in electricity demand at the same time as it addresses problems of air pollution, water resource shortages, and climate change. In developing coordinated institutional, policy, and regulatory responses to these interrelated challenges, China has demonstrated many notable innovations.

i. Flue Gas Desulfurization

It is widely recognized that China's economic growth has come at a high environmental cost. The 11th Five Year Plan (FYP), which laid out national strategic goals for the period of 2006 to 2010, was the first during which mandatory pollution reduction objectives were successfully achieved. In the area of air quality, the 11th FYP sought a 10-percent reduction in emissions of sulfur dioxide below 2005 levels, a goal accomplished through the shuttering of small, inefficient coal-fired power plants and the wide-scale installation of flue gas desulfurization (FGD) equipment on larger new and existing units.

Since launching efforts in 2006, China's deployment of FGD equipment has been aggressive; by the end of 2010, 86 percent of coal-fired units had installed scrubbing equipment.[81] By comparison, the United States, which has regulated sulfur dioxide (SO_2) since the 1970s, had only some 60 percent of units operating FGD by the end of 2010.[82] China achieved this rapid rate of deployment through government subsidization of installation costs. However, operating costs – costs largely associated with the electricity required to run the equipment, typically 1 to 2 percent of output – continued to pose a disincentive. As of 2007, the State Environmental Protection Agency (now the Ministry of Environmental Protection) estimated that less than 40 percent of plants with FGD were actually operating the scrubbers continuously.

To remedy this, China instituted an incentive scheme for generators to operate the equipment. But it was not until the payments were linked to real-time emission data that the policy proved effective. In situ continuous emissions monitoring systems (CEMS), installed in the smokestacks of plants with FGD, produce emissions data shared between the environmental regulator, which is in charge

81 Mao & Hu, 2012.

82 U.S. Department of Energy, Energy Information Administration, 2011.

of administering the monitors, and the State Electricity Regulatory Commission (SERC), which is in charge of administering the price premium for generators. The scheme offers an incentive equivalent to US$2.00 per MWh for generators with scrubbers at 100 percent operation rate, declining to no incentive payment for operational rates below 80 percent. For scrubbers that do not operate at all, a penalty is levied equivalent to US$9.90 per MWh.[83]

As Figure 7 shows, generators responded quickly to the incentive. In Jiangsu, where the CEMS data sharing was first piloted, compliance improved dramatically over its 28 GWe of FGD equipment, increasing operational rates from 62 to 97 percent over a three-month period in 2007. As Figure 7 illustrates, this improvement in compliance resulted in more than a 75-percent drop in ambient SO_2 concentrations in the province. Since this initial trial, the scheme has been expanded nationally with similar results.

ii. Small Plant Closures

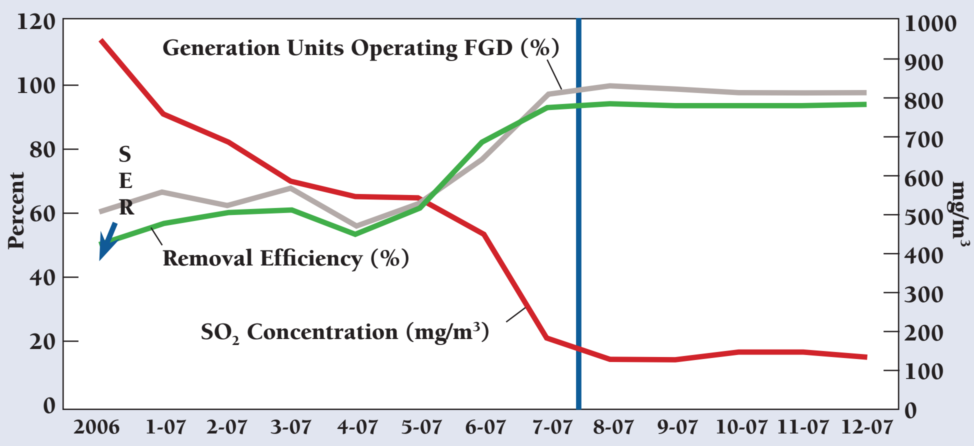
The second prong of the 11th FYP SO_2 emissions reduction program, the shuttering of smaller, inefficient, and often outdated coal-fired power plants, also highlights shared priorities between the energy and environmental agencies. According to government estimates, China's small coal-fired units, 50 MW and smaller in size, typically burned between 130 and 210 percent more coal per unit of electricity output than units 300 MW and larger.[85] Smaller plants also were generally deemed too small for desulfurization treatment to be cost-effective. Therefore, replacing these smaller units with new, more efficient facilities would simultaneously reduce SO_2 emissions and improve the efficiency of the power sector.

Administered by the SERC, the "small plant closure program" phased out roughly 60 GW of generating units nationwide between 2006 and 2010. It did this primarily through the rescission of operating permits and the establishment of "generation allowances" as an asset to be traded from smaller to larger units to ameliorate the financial impact of early retirement. SERC oversaw these transactions and was responsible for ensuring the prices paid to smaller generators for these allowances would roughly compensate for the tariffs they would have received under normal operations.[86] Applications for new coal-fired plants that included generation allowances purchased from closed units were given priority approval. In some cases, the electricity regulator also lowered the tariff rates paid to small, polluting generators to encourage them to shut down.[87]

Over this five-year period, the proportion of plants under 100 MW in size declined from 30 to 14

Figure 7

Operator Response to Scrubber Incentive, Jiangsu Province, China, 2007[84]



Indicator	2006	Jan-May 2007	June 2007	June-Dec 2007
Units Operating FGD (%)	60.7	63.1	77.31	98.15
Desulfurization Rate (%)	51.6	59.2	82.2	93.8
SO_2 Concentration (mg/m^3)	952.24	622.8	450.27	143.26

83 Yuan et al, 2009.

84 China State Electricity Regulatory Commission, 2008.

85 National Bureau of Statistics of China, National Development and Reform Commission, and the Asian Development Bank, as presented by the University of Cambridge Electricity Policy Research Group, 2008.

86 State Electricity Regulatory Commission, 2008.

87 Weston et al, 2009.

percent, as total generation grew by 50 percent.[88] This restructuring effort is especially impressive when viewed in contrast to the practice of "grandfathering" employed in the United States, EU, and elsewhere, which grants exemption from environmental regulation to existing polluting facilities, often permitting them to continue to run for years after their intended operational life. Widely regarded as an environmental success, the closure program has been expanded in China's 12th FYP.

iii. Urban Air Quality

China's more recent efforts to improve urban air quality also show a strong commitment to coordinating energy and environmental regulation. In 2010, the State Council, China's highest administrative body, approved regulations on the Joint Prevention and Control of Air Pollution to Promote Regional Air Quality,[89] which set out a broad agenda for air quality management in key economic and population centers across the country.[90] These regulations and subsequent guidance documents put forth by the Ministry of Environmental Protection and local authorities focus on a clean energy transformation as the cornerstone of multipollutant emissions control.[91] Issued in March 2012, the air pollution management plan for the Municipality of Beijing, for instance, seeks aggressive reductions in ambient concentrations of $PM_{2.5}$, PM_{10}, SO_2, NO_2, and ozone through an overhaul of the transportation sector and a cap on coal consumption.[92] Remarkably, the coal cap represents a more than 10 million ton reduction in annual coal consumption across a range of economic sectors – that equates to a 43-percent cut below 2010 levels by 2015. The municipality aims to accomplish the cap through a portfolio of crosscutting measures, including:

- An electricity portfolio standard with a minimum of 60 percent natural gas and 8 percent renewable energy and a maximum of 10 percent coal;
- The closure of three large coal-fired power plants;
- A moratorium on energy-intensive industries, such as oil refineries, petrochemicals, cement, iron, and steel, including all new construction, retrofits, and expansions, and a phase-out of some 1,200 existing facilities in these industries;
- Widespread conversion of small coal-fired boilers to natural gas, achieving a ban on coal in the metropolitan districts; and
- The expansion of natural gas distribution networks to the outer suburbs to promote fuel switching from coal to gas in the residential, commercial, and industrial sectors.

Responsibility for implementation of these various measures has been allocated to Beijing's energy, economic, and environmental agencies. Although it is too soon to track how effective interagency coordination will be, it is likely that the government will be able to build on the strong track record of the 2008 Olympic experience.

B. Ozone Transport Commission's High Electric Demand Day Project

An example from the United States provides additional insight into how energy and environmental regulators can address mutual problems in a collaborative fashion. This example is marked by the successful manner in which regulators from different disciplines were able to form strong working relationships that, in turn, led to solid policies benefitting both the power sector and the environment.

The Ozone Transport Commission (OTC) is a multistate organization created under the Clean Air Act. The OTC is responsible for advising the EPA on transport issues and for developing and implementing regional solutions to the ground-level ozone problem in the northeast and mid-Atlantic states.[93] The OTC's commissioners generally are the environmental regulators from each of its 13 member

88 China National Energy Agency, 2009.

89 China State Council, 2010.

90 The rule initially focused on nine key regions, with the expectation that success and lessons will later be applied more broadly. These nine key regions are: Beijing-Tianjin-Hebei region around Beijing Municipality, the Yangtze River Delta around Shanghai, the Pearl River Delta around Guangzhou, and six city-clusters consisting of the areas around Shenyang-Changsha-Wuhan, Chengdu-Chongqing, the Shandong peninsula, and the coastal area across the straits from Taiwan. The number of participating regions has since expanded, with three additional city-clusters developing air quality plans as of July 2012.

91 For example, Ministry of Environmental Protection, 2010.

92 Beijing Municipal Government, 2012.

93 Retrieved from www.otcair.org on May 29, 2012.

jurisdictions.[94] Beginning in 2006, the OTC invited its commissioners and their staff, energy regulators from its member states, and several stakeholder and advisory entities to form a workgroup to study the occurrence and impacts of HEDD.[95] The OTC's initiative to bring this diverse group of parties together is exactly the kind of multidisciplinary thinking for which this paper advocates.

The workgroup recognized that HEDDs not only create peak load conditions for the electric system but also have profound ramifications for air quality. For example, energy regulators were concerned that reliability requirements necessitated maximizing operating capacity and shedding load. This response had deleterious consequences for air quality, however, because it typically took the form of industrial customers operating dirty, on-site diesel generator sets, the emissions from which compounded the critical air pollution loadings in the atmosphere experienced on HEDDs. Because of air conditioning loads, HEDDs tend to coincide with the hottest summer days, so ground level ozone problems are often at their worst. Thus, one of the driving paradigms of the workgroup was that energy decisions had to be informed by air quality goals and that air quality strategies had to be informed by energy reliability considerations.

As a result of the workgroup's efforts, the OTC adopted a *Memorandum of Understanding Among the States of the Ozone Transport Commission Concerning the Incorporation of High Electrical Demand Day Emission Reduction Strategies Into Ozone Attainment State Implementation Planning* ("Memorandum").[96] The Memorandum acknowledges that HEDD unit operations are significant contributors to NO_X emissions on high ozone days, and it sets out a series of potential actions signatory states planned to incorporate into their State Implementation Plans (SIPs) for ozone, such as:[97]

- Regulatory caps for emissions from HEDD units on HEDDs;
- Performance standards;
- State/generator HEDD partnership agreements;
- Energy efficiency programs;
- Demand response programs, provided that such programs reduce and/or preclude the installation or use of distributed generation with unacceptably high emissions;
- Regulatory standards or controls for behind-the-meter generators; and
- Effective adjustment of the NO_X retirement ratio to provide greater reductions on HEDDs.

As part of the Memorandum, several OTC states agreed to pursue specific NO_X emissions reductions, to be achieved no later than 2012, as illustrated in Figure 8.

The results from the signatory states have varied, but each of the six states has taken action based on the Memorandum. Some examples of the measures that states have adopted include the commissioning of new, cleaner generation for peaking plants; the adoption of demand response programs aimed at shaving peak usage; initiating

Figure 8

OTC NO_X Emissions Reduction Targets

State	NOx (Tons per Day)	Percent Reduction from HEDD Units
Connecticut	11.7	25%
Delaware	7.3	20%
Maryland	23.5	32%
New Jersey	19.8	28%
New York	50.8	27%
Pennsylvania	21.8	32%
Total	**134.9**	

Source: Memorandum of Understanding Among the States of the Ozone Transport Commission Concerning the Incorporation of High Electrical Demand Day Emission Reduction Strategies Into Ozone Attainment State Implementation Planning, 2007.

94 Governors from each state and the District of Columbia designate two representatives to serve as OTC commissioners. They are typically – but not always – the environmental commissioner or secretary for the state and its air director.

95 HEDDs are those hottest days of the year when electricity use peaks to its highest levels for the year and when ozone forming air pollution is at its worst due to the reliance on additional electric generating units.

96 See Memorandum of Understanding. Accessed June 5, 2012, at http://otcair.org/upload/Documents/Formal%20Actions/OTC_2007_SpecialMtg_%20HEDDMOU_Final_070302[1].pdf

97 Id.

performance standards for HEDD units; requiring HEDD units to fuel switch to cleaner fuels; and requiring the installation of pollution control technologies. Connecticut has been particularly successful in its efforts, having met its HEDD obligation by 2007 and every year since.[98]

C. The Regional Greenhouse Gas Initiative

The RGGI is a market-based carbon management program developed and implemented by the ten northeastern and mid-Atlantic US states – Connecticut, Delaware, Maine, Maryland,[99] Massachusetts, New Hampshire, New Jersey,[100] New York, Rhode Island, and Vermont. RGGI is an excellent example of how environmental and energy regulators can collaborate to jointly address interrelated environmental and energy issues, in RGGI's case the emissions of CO_2 from electric power generating facilities.

RGGI was born of an idea by George Pataki, then Governor of New York, who in April 2003 wrote to his fellow governors in the northeastern and mid-Atlantic states, seeking their help in developing a regional strategy that would help lead the nation in addressing global climate change. After nearly a year of preparatory work, the RGGI working group was formed to develop a workable program that could be adopted by the states. From the very start, the working group was comprised of both utility and environmental regulators from each participating state, as well as a host of stakeholders from the advocacy and business communities. Innumerable communications, e-mails, meetings, and information sharing marked these early stages. Staff worked closely with the specific aim of identifying and addressing both environmental and energy concerns.

In addition to stakeholder meetings and individual communications, there were a number of topical workshops dealing with various technical details of the future RGGI program, such as emissions offsets, allocation of allowances, auction design, electric market structure, electric imports, and emissions leakage.[101] Furthermore, a Staff Working Group, made up of representatives from each of the participating states, worked together to develop documents and analysis to help each state adopt its own implementation of RGGI's CO_2 budget trading program. This extensive series of meetings gave regulators the opportunity to thoroughly understand the policies and technical aspects of the program and to craft viable solutions that addressed both energy and environmental concerns. By August 2005, the Working Group had developed and proposed a GHG cap-and-trade program that would commence in 2009 and stabilize GHG emissions at average 2002-2004 levels by 2015.

The goal of RGGI is to cap and reduce the power sector's CO_2 emissions by 10 percent by 2018.[102] Each participant state maintains sovereign participation in RGGI, based on individual state legislation and/or regulation grounded in the RGGI Model Rule. Each state program limits CO_2 emissions by issuing CO_2 allowances and by requiring participation in a regional CO_2 allowance auction. Regulated power plants can use CO_2 allowances issued by any participating state to demonstrate compliance with an individual state program. Thus, by aggregating their participation, the states function as a single regional compliance market for CO_2 emissions.[103]

Although not required in the initial RGGI Memorandum of Understanding (MOU), the states universally decided to auction – rather than to allocate – emissions allowances. The result of this groundbreaking decision legitimized and substantiated the auctioning of allowances as the most effective way to distribute allowances. It readily led to the

98 Information on HEDD performance was acquired from a May 17, 2011 presentation to the OTC's Air Directors Meeting entitled "Update on High Electric Demand Day Efforts."

99 Maryland joined RGGI in April 2007, when Governor Martin O'Malley signed an agreement to join.

100 While New Jersey's Governor Christie has pulled New Jersey from RGGI membership, it is unclear whether the Governor has authority to do so and a lawsuit by Environment New Jersey and NRDC is now pending.

101 See www.rggi.org for documents associated with all of these activities.

102 The RGGI cap is the total number of CO_2 allowances issued by participating states and establishes a regional budget for CO_2 emissions from the power sector. From 2012 to 2014, the RGGI cap is 165 million short tons of CO_2 per year. Beginning in 2015, the cap will decrease by 2.5 percent per year, for a total reduction of 10 percent by 2018. Retrieved on September 26, 2012, from http://www.rggi.org/docs/Documents/RGGI_Fact_Sheet_2012_09_07.pdf

103 Retrieved on May 7, 2012, from http://www.rggi.org/design

institution of a single region-wide allowance auction (rather than individual state auctions), which in turn reinforced the regional character and the effectiveness of the program.

RGGI recently finished its first compliance period, which ran from 2009 to 2011, and it has been a tremendous success in terms of reducing CO_2, generating solid economic benefits for the region, and driving investment into energy efficiency. From 2008 to 2009, electricity load in the ten-state RGGI region decreased by 17.3 million MWh, or 3.7 percent, and total electric generation region (fossil and non-fossil) dropped by 19.5 million MWh, or 5.1 percent.[104] At this rate, the RGGI states are on pace to meet or exceed their emissions targets.[105] As of the June 6, 2012 auction, participating states have auctioned off $1,045,921,078 worth of emissions allowances, and most states have invested the proceeds primarily to fund energy efficiency and conservation programs.[106] Overall RGGI has produced $1.6 billion in net present economic value to the RGGI region,[107] and "the first three years of RGGI will lead to over 16,000 new job-years, with each of the ten states showing net job additions."[108] RGGI also has led to over a half billion dollars in investment into energy efficiency programs in participating states.[109]

Despite its success, RGGI faces challenges. There is ongoing debate about how to deal with the problem of non-RGGI-affected generation exporting energy into the RGGI region (i.e., "leakage"), including whether it even occurs at all.[110] The RGGI region acquires energy from three sources: generation within the region that is covered by the RGGI program; generation within the region that is not covered by RGGI (e.g., smaller generators <25 MW); and generation located outside the region that is not covered by RGGI but may export energy into the RGGI region. This latter category of sources is not required to obtain emissions allowances. The failure to track and address GHG emissions from this category is a concern that requires additional analysis and may necessitate a policy response by the RGGI states.

RGGI has a comprehensive program review scheduled in 2012, and leakage is one of the issues to be considered. That such technical and programmatic challenges arise as part of the growing pains of any major new regional initiative is hardly surprising, but it suggests that ongoing collaboration between environment and energy regulators is both necessary and appropriate. Just as combined skills and insights of environmental and energy regulators successfully gave birth to the RGGI model, it is their combined skills and insights that will shepherd the program in effectively meeting future challenges like leakage.

State regulators' experience effectively working together across energy and environmental domains to initiate RGGI has spurred additional cross-regulatory efforts in other sectors in the region. Specifically, on December 30, 2009, the governors of the participating RGGI states and Pennsylvania signed an MOU to "work to develop a low-carbon fuel standard to reduce greenhouse gas emissions from cars and trucks despite objections from the oil industry." This accord initiated the development of "a proposed framework to be completed" and mirrors plans in California "to reduce the carbon footprint of transportation fuels."[111]

D. The Energy and Water Nexus

Water is used in a number of different ways in power generation and power plant operations. A distinction must be drawn, however, between consumptive uses of water (e.g., evaporation) and non-consumptive uses, such as cooling water withdrawals in which water is used and then returned to its source water body. Water generates electricity directly in hydroelectric plants (a non-

104 RGGI, Inc, 2011.

105 Environment New Jersey, 2012.

106 Environment Northeast, 2012.

107 Hibbard et al, 2011.

108 Id.

109 Environment Northeast, 2012.

110 RGGI also faces challenges to its very existence. In 2010, fossil-fuel interests commenced intense lobbying in the states to undo RGGI. For the most part, this effort has been unsuccessful: only New Jersey left RGGI when Governor Chris Christie announced in May 2011 that his state would leave the program. However, NRDC and Environment New Jersey have filed suit contending that the state's pull out afforded neither proper notice nor opportunity to comment, in violation of the state's Administrative Procedure Act (see http://www.environmentnewjersey.org/news/nje/christie-administration-sued-illegally-leaving-regional-clean-energy-pact, accessed on June 12, 2012).

111 Governors sign low-carbon accord, 2009.

consumptive use), but these plants lose a large amount of water due to surface evaporation from their large impoundments (a consumptive use).[112] Thermoelectric plants (e.g., coal, oil, nuclear) heat water to create steam to drive a turbine to generate power and then use condensers to cool the steam after it is exhausted from the turbine.[113] Cooling water is discharged into reservoirs or other water bodies.

The cumulative impact of this use is significant: in 2008, water-cooled thermoelectric power plants in the United States withdrew 60 to 170 billion gallons from freshwater sources daily and consumed 2.8 to 5.9 billion gallons of that water.[114] Thermoelectric generation accounts for roughly 39 percent of water withdrawals and 53 percent of total water consumption in the United States.[115] Approximately 1/2 gallon of water is consumed through evaporation for every kWh of thermoelectric generation consumed at the point of end use.[116] There is also a compounding "feedback loop" because energy is required to source, treat, distribute, and clean water. There is, as ACEEE puts it, lots of water embodied in energy and lots of energy embodied in water.[117] For example, in California, 20 percent of the state's energy consumption is used to gather, purify, and distribute water.[118]

Conventional thermoelectric generation requires a reliable and predictable source of water. When this supply is threatened, system reliability can be compromised. If stream and reservoir levels drop too low as a result of drought, steam electric power plants may not have sufficient water to continue full operation and may find it necessary to derate their output or cease operating altogether. Water temperature also plays an important role. As water becomes warmer, its effectiveness as a coolant diminishes. This can also necessitate the derating of thermoelectric generating units, which can further impair reliability.

Recent experience in Texas illustrates the potential impact of drought on power generation. Each kWh produced by steam-electric generation in Texas requires up to 30 gallons of water withdrawal and consumes 0.3 to 0.6 gallons of that water.[119] In 2011, Texas suffered one of the worst droughts and heat waves in its history, and the reliability of its power system was brought into question. At least one small, 24-MW generating unit was curtailed due to a lack of adequate cooling water, a small example of the larger looming problem if drought and heat waves continue. Trip Doggett, President and CEO of the Electric Reliability Corporation of Texas (ERCOT), has indicated that persistent drought conditions in Texas are impacting electric generation resources. Although significant generation shortfalls in 2012 are unlikely, if drought conditions continue into 2013, consequences to unit availability – and thus reliability – are likely to become more severe.[120]

Serious drought problems also struck central China in 2011, causing particular problems for the Yangtze River delta, a region that supports 400 million people and 40 percent of China's economic activity.[121] The drought made drinking water scarce in some areas, constrained farmers' ability to irrigate their crops, and reduced to the lowest levels in years the rivers and reservoirs serving many of the hydroelectric dams that generate significant portions of China's electricity. In May 2011, the reservoir serving the world's largest hydroelectric plant, the Three Gorges Dam in Hubei Province, fell to 152.7 meters, below the 156-meter mark required to run its 26 turbines effectively.[122] Water availability posed a serious risk to output from the Three Gorges Dam's 18.2-GW capacity.[123] State Grid, China's largest state-owned power distributor, reported that "10 of its provincial-level power grids were suffering severe shortages due to the drought's impact on hydroelectric generation, including Shanghai and the heavily populated southwestern Chongqing region."[124] In 2012, by contrast,

112 Torcellini, Long, & Judkoff, 2003, p. 9.

113 U.S. Department of Energy, 2006, p. 18.

114 Averyt et al, 2011.

115 Torcellini, Long, & Judkoff, 2003.

116 Id.

117 ACEEE, 2011.

118 How saving energy means conserving water in U.S. West, 2011.

119 King, Duncan, & Webber, 2008, p. 1.

120 ERCOT President & CEO, Trip Doggett, 2012.

121 Watts, 2011.

122 Stanway, 2011.

123 As of its completion in July 2012, the dam includes 32 turbines totaling 22.5 GW of capacity.

124 Saiget, 2011.

Figure 9

Examples of Problems Reflecting the Water-Energy Nexus[125]

Year	Region/ Country	Climate Event	Consequence
2011	Texas, US	*Drought and heat wave*	Farmers, cities, and power plants compete for the same limited water resource. After the driest 10 months on record (since 1895), at least one plant was forced to cut its output, and some plants had to pipe in water from new sources to maintain generation. If the drought continues throughout 2012, several thousand MW of electricity may go offline (O'Grady, 2011; Averyt et al., 2011).
2010	Washington State, US	*Low snowpack, followed by heavy rains*	Given changes in precipitation regime, the peak stream flows were not aligned with power projections, straining hydropower generation and affecting electricity prices (Averyt et al., 2011).
2010	Lake Mead, NV and AZ, US	*Low water levels*	Lake Mead water levels dropped to levels not seen since the 1950s, prompting the US Bureau of Reclamation to reduce the Hoover Dam's generating capacity by 23% (Walton, 2010; Averyt et al., 2011).
2007	North Platte River, NV and WY, US	*Extended drought*	After a seven-year drought, power generation from the North Platte Project, which includes hydropower plants on North Platte River, was reduced by about 50%. A Laramie River coal-fired Station (WY) was at risk of insufficient cooling water and avoided impacts to power production by consuming water from local irrigation districts and the High Plains aquifer (Cooley et al., 2011; Averyt et al., 2011).
2006	Midwest, US	*Heat wave*	Nuclear plants forced to reduce output at time of peak demand; high river water temperatures, typically used for cooling, forced a MN plant to reduce generation by 50% (Averyt et al., 2011).
2006	Uganda	*Drought*	Hydropower capacity was reduced by one third, with subsequent electricity shortages (Collier, 2006).
2003	Germany	*Heat wave*	Increased river water temperatures led German authorities to close a nuclear power plant and reduce output at two others (Cooley et al., 2011).
2003	France	*Heat wave*	Increased river water temperatures induced the French government to shut down 4,000 MW of nuclear generation capacity (Cooley et al., 2011).
2001	Brazil	*Drought*	Combined with increased energy demand, country experienced "virtual breakdown" of hydroelectricity and reduced GDP (Bates et al., 2008).

the dam sustained its most serious test to date in a series of record flood peaks. Hydroelectric power output has surged.

India has been facing severe water pressures on its power generation infrastructure as well, which under current trends seem likely to intensify into the future. Burgeoning economic growth has exponentially increased energy demand in the country, a large portion of which remains unmet. India relies on coal and hydro as the major sources of electricity generation, both of which require significant amounts of water for operational use. Increasing water needs in the energy sector compete with increasing demands from rapidly growing urban areas, and also from agriculture, which is the largest consumer of water. These

125 SEI, 2012.

conflicting needs, compounded by warming weather and depleting water resources, have led to frequent situations in which power generation has had to be curtailed due to a lack of water.

An illustrative example is the shutdown of the Raichur Thermal Power Station (RTPS) in April 2012. RTPS is a coal-fired electric power station located in the southern state of Karnataka.[126] It has an installed capacity of 1,720 MW, and it supplies around 40 percent of the total electricity generated in the state. The plant needs about 200,000 cubic meters of water per hour from the Krishna River for cooling.[127] In April 2012, high temperatures, coupled with extensive sand mining along the river basin and farmers drawing water for irrigation, led to reduced flow in the river, cutting water availability to around 2,000 cubic meters per hour. Of the eight units in RTPS, four were forced to shut down due to inadequate water supply for cooling, dropping the generation to 50 percent of the installed capacity.[128] The shutdown resulted in power cuts that lasted 6 to 12 hours a day, plunging many parts of the state into darkness. RTPS was finally restored to its operating capacity after water was released from nearby dams, which was initially conserved for meeting the needs of the cities, towns, and villages along the river basin.[129] With many more coal and nuclear plants planned for meeting India's growing energy needs, these kinds of situations will only become more common.

These examples, while profound, are merely illustrative. A recent analysis by van Vliet et al[130] concluded that thermoelectric generation in Europe and the United States (78 and 91 percent of total generation, respectively) is vulnerable to climate change owing to the combined impacts of lower summer river flows and higher river water temperatures. This study found a summer average decrease in power plant capacity of 6 to 19 percent in Europe and 4 to 16 percent in the United States, depending on cooling system type and climate scenario for 2031–2060. In addition, it found that the probability of extreme (>90 percent) reductions in thermoelectric power production will increase by a factor of three on average.

These examples raise the question of whether, when considering power system planning or the construction of new power facilities, energy regulators are adequately incorporating water concerns. Given the existing scarcity of water in some areas, and the increasing likelihood of greater water scarcity and more extreme weather events as the earth warms, the water-energy nexus provides yet another critical reason for energy and environmental regulators to collaborate closely in reaching appropriate electricity resource decisions.

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126 For more information see Karnataka Power Corporation, Ltd at http://www.karnatakapower.com/raichur.htm

127 Id.

128 *The Times of India* (April 25, 2012). Closed Raichur Thermal Power Station units may start running tomorrow. http://articles.timesofindia.indiatimes.com/2012-04-25/bangalore/31398638_1_rtps-raichur-thermal-power-station-power-cuts

129 *The Hindu* (April 24, 2012). States on the Verge of Power Crisis. http://www.thehindu.com/news/states/karnataka/article3346575.ece

130 van Vliet et al, 2012.

Appendix B

Modern modeling approaches now appear capable of addressing the complex web of energy, environmental, social, technical, and economic interrelationships. Two approaches in particular merit special consideration: optimization modeling and system dynamics modeling.

Optimization modeling evolved from mathematical problem-solving techniques (e.g., linear programming) in the 1930s and 1940s. It is in widespread practice today with numerous commercially available platforms and multiple firms providing it as a service. Sophisticated optimization modeling can be done using commonly available spreadsheet software, and many already developed applications are available at little or no cost. Components of optimization models typically consist of: (1) data inputs (e.g., resource options, performance characteristics, costs, emissions rates), (2) one or more objectives, (3) decision variables (actions or choices that can be carried out in pursuit of the objective), and (4) constraints. Given the data inputs and options for actions or choices, the model identifies optimal outcomes in terms of the defined objectives, subject to the constraints specified. Implementation and results lead to refinement of the model, enabling iterative improvement.[131] Optimization modeling is an effective tool for identifying optimal strategies within complex systems, and many optimization models have been developed to serve specific needs in the energy sector, including emissions mitigation.[132, 133]

System dynamics is a powerful methodology and computer simulation modeling technique for framing, understanding, and discussing complex issues and problems. System dynamics differs from other approaches to studying complex systems in that it incorporates feedback loops, mutual causality, time delays, inventory and capacity changes,[134] and nonlinearity that affect the behavior of entire systems over time. Originally developed in the 1950s to help corporate managers improve their understanding of industrial processes, modern graphical user interfaces have simplified its development and use, and system dynamics is currently employed throughout the public and private sector for policy analysis and design.[135] Energy policy is well suited for a system dynamics approach, because the study, design, and implementation of national energy policy must not only appreciate the complexities of the energy sector, but how energy issues interact and influence other policy concerns, such as economic growth, technology development, national security, international trade, fuel poverty, and the environment.[136]

As powerful as these tools are, to date there appears to be relatively little appreciation or use of these models by government energy and environmental policymakers in an integrated fashion involving, for example, electricity supply choices, reliability concerns, energy efficiency opportunities, emissions impacts, water consumption, and cost. The resources necessary to develop and maintain such models can be significant in the context of limited jurisdictional budgets. They can often be developed for application at a regional level, however, and thus shared across multiple jurisdictions. Furthermore, the societal costs of not analyzing, identifying, and implementing optimally integrated energy and environmental policies can be profound. Two notable exceptions where system

131 Goren et al, 2008.

132 Feng et al, 2011.

133 It is worth noting that determining the objective set is the policy challenge. Different results can be expected if the objective is limited to least cost, compared to an objective set that layers in reliability and environmental compliance.

134 In the language of system dynamics, inventories and changes to inventories (capacity) are referred to as “stocks” and “flows.” Stocks refer to the absolute levels of accumulated goods or capacity. Flows refer to the rate at which the stocks either accumulate or release additional inventory.

135 See http://sdg.scripts.mit.edu/Publications.html

136 Radzicki & Taylor, 1997.

dynamics are used are in Vermont, where the Department of Public Service applies it in modeling electricity demand forecasts, and in the EU, where advanced systems analysis is used by the International Institute for Applied Systems Analysis to inform key policy processes and international negotiations on clean air and GHG mitigation.

The Regulatory Assistance Project