Integrated, Multi-pollutant Planning for Energy and Air Quality (IMPEAQ)

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This paper represents RAP's early-stage of thinking on IMPEAQ. We invite your comments and constructive criticism.

1. Executive Summary

In 1970, the U.S. Congress passed the Clean Air Act (Act) to authorize the development and implementation of consistent, national level plans to improve air quality and public health. The Act, its revisions, and implementing regulations dictate how states[1] and EPA develop air quality plans. The Act established six individual criteria pollutants, and states are required to develop plans to demonstrate how their air quality will meet the health-based standards set for each of the criteria pollutants.

Significant progress has been made in reducing criteria and hazardous air pollutants and improve public health. However, about 50% of Americans still live in areas where at least one criteria pollutant exceeds standards.[2] And the levels of today's U.S. air quality standards are less protective than those recommended by the World Health Organization (WHO), and, in certain important instances, weaker than the levels recommended by EPA's Clean Air Scientific Advisory Committee (CASAC).[3] In addition, over time some of the specific requirements of the Act and related regulations have had the unintended and unnecessary consequence of limiting the development of more effective air pollution policies. Further, the Act's specific requirements are generally regarded as prescriptive rather than what they really are: minimum federal requirements that can be met or exceeded through ever improving and more effective options.

[1] Throughout this document, we use "state" as shorthand to describe the air quality planning that is done by states, local agencies, and Tribal Nations.

[2] A total of 154,454,000 people live in a nonattainment area for at least one pollutant vs. the U.S. population of 311,592,000. See http://www.epa.gov/oar/oaqps/greenbk/popexp.html.

[3] The World Health Organization recommended $PM_{2.5}$ guidelines are an annual standard of 10 ug/m^3 and 24-hour standard of 25 ug/m^3. The Clean Air Scientific Advisory Committee recommended that EPA adopt a revised ozone standard in a range between 60-70 parts per billion. The current EPA standards for $PM_{2.5}$ are an annual standard of 15 ug/m^3 and a 24-hour standard of 35 ug/m^3. The current EPA standard for ozone is 75 parts per billion.

Two reforms are especially important: one is the application of long-term integrated least-cost planning analyses that have long been used in the energy sector (often called "integrated resource planning" or "IRP"); the other is the need to approach air pollution as a multi-pollutant problem rather than regulating discreet pollutants individually. *How* these problems are addressed is equally critical. This paper's premise is that increasing the efficiency of energy production and consumption is cost-effective, can enhance the reliability and affordability of electric and gas service, and also represents an important opportunity to improve air quality, reduce hazardous air pollutants, and protect public health and the Earth's climate.

In short:

- Long-term, integrated, least-cost planning for air quality means conducting analyses of the efficacy and costs of control measures to meet current and future air quality standards looking forward over a 20-year period. This type of planning considers measures and standards at all points of regulation, including "root-of-pipe" programs like energy efficiency and clean demand response, process changes (e.g., maintaining or improving upon a product's functionality with lower energy consumption and environmental impacts), and "end-of-pipe" measures like air pollution control devices. Long-term, integrated, least-cost planning for air quality determines the ability of control measures to concurrently reduce several pollutants, and any cross-pollutant affects.[4]
- A multi-pollutant focus is needed because, when people breathe a parcel of air, their lungs encounter whatever combination of pollutants exist in that parcel and experience the health effects of those pollutants. Likewise, animals, plants, and the built environment are affected by the combination of all pollutants. While nothing in the Clean Air Act stipulates that state air quality plans must adhere to a mono-pollutant regimen, the Act does little to encourage multi-pollutant approaches. The Act and its derivative regulations, in focusing on individual criteria pollutants, implicitly compel regulators to deal with the criteria pollutants individually. The unintended consequences of addressing pollutants individually include tradeoffs where some emissions may increase or where additional costs may be imposed on the energy sector.[5] Environmental and energy regulation will always have tradeoffs, of course, but in the multi-pollutant process described in this paper, such tradeoffs can be explicitly revealed, constraints evaluated, and future policies prioritized. We encourage air

[4] The focus of this paper is on the air/energy nexus. However, we know that our energy choices also influence water consumption and quality – and vice versa. We would expect the IMPEAQ process to evolve to also integrate evaluation of policies for the water/energy nexus, in effect becoming a comprehensive air/water/energy approach

[5] Examples: Biomass energy policies pursued in some states to increase renewable energy generation may cause fine particle and oxides of nitrogen (NO_X) emissions to increase. Increased penetration of electric vehicles can reduce hydrocarbon emissions, but may increase NO_X, SO_2 and fine particle emissions.

> regulators to rethink and significantly alter their existing approach because it is clear that a multi-pollutant process will improve air quality, reduce public health impacts, and utilize state agency resources more efficiently.[6]

The idea of addressing air quality from a holistic, multi-pollutant perspective is not new. Several papers and books have been written on this topic – with the authoritative 2004 National Academy of Sciences report[7] being the most comprehensive – and made several recommendations for EPA, state, and local air quality agencies to consider toward adopting multi-pollutant approaches. Economic models also conclude that reducing multiple air pollutants through root-of-pipe measures (e.g., at the beginning of manufacturing processes) is far more cost-effective than multiple pollutant-specific approaches focused only at the end of the pipe. The three, national, U.S. associations of air quality and energy regulators and state energy offices[8] have also convened several conferences and workshops over the last 15 years, exploring areas where mutual efforts could help achieve the joint objectives of improved air quality and reliable, affordable electricity service.

This paper is RAP's initial effort to develop a model process – which we call Integrated, Multi-pollutant Planning for Energy and Air Quality (IMPEAQ) – that states, local agencies, and EPA can apply to comprehensively and simultaneously reduce all air pollutants: criteria, toxic, and greenhouse gases (GHGs). IMPEAQ seeks to adhere to Integrated Resource Planning (IRP) principles by trying to identify – through optimization and/or systems dynamics modeling – least-cost pathways to reduce emissions of multiple pollutants. In doing so, IMPEAQ also seeks to minimize impacts on electric reliability and other system impacts. To be clear, a process like IMPEAQ is not likely to – nor does it intend to – create a plan that distributes control measures and costs evenly across all sectors (e.g., power plants, refineries, vehicles, area sources, etc.). Least-cost controls are likely to be concentrated in some sectors. "Fairness" among sectors is thus not a criterion in deciding which sectors should shoulder pollution control burdens. The best process will achieve targeted air quality results at the lowest societal cost.

This framework will be shared with air quality and environmental experts to examine, review, and compare to their own concepts of air quality planning. New regulations or revisions to the Clean Air Act are not necessary. As evidenced by pilot efforts like those in the Bay Area Air Quality Management District, Maryland, New York State, North Carolina, and St. Louis, adequate flexibility exists within existing standards and guidance to allow multi-pollutant planning to

6 While we emphasize air quality and public health benefits here, a multi-pollutant process can also improve water quality, reduce water consumption and production of solid and hazardous wastes, and reduce insurance costs at companies.

7 National Research Council, Committee on Air Quality Management in the United States, "Air Quality Management in the United States", 2004.

8 The National Association of Clean Air Agencies (NACAA), National Association of Regulatory Utility Commissioners (NARUC) and National Association of State Energy Officials (NASEO).

occur. These efforts have demonstrated "proof of concept": multi-pollutant planning can work. To make multi-pollutant planning routine, additional examples and state, local, and EPA leadership are needed to:

- Demonstrate how multi-pollutant planning can be accomplished;
- Develop new tools and help to develop, refine, and validate the application of existing tools and methods utilized; and
- Develop skilled professionals who represent the next generation of air quality planners.

This paper is just one of the many resources states can draw upon to help develop multi-pollutant plans. It may be among the first, however, to explicitly target least-cost approaches analogous to utility IRP efforts, to lead from a premise of efficient energy consumption, or to internalize electric reliability considerations. Our goal in this paper is to elicit constructive criticism, refine its key points and messages, and to provide a document that could become a basis for new, more cost-effective and public health protective air quality plans.

2. Introduction

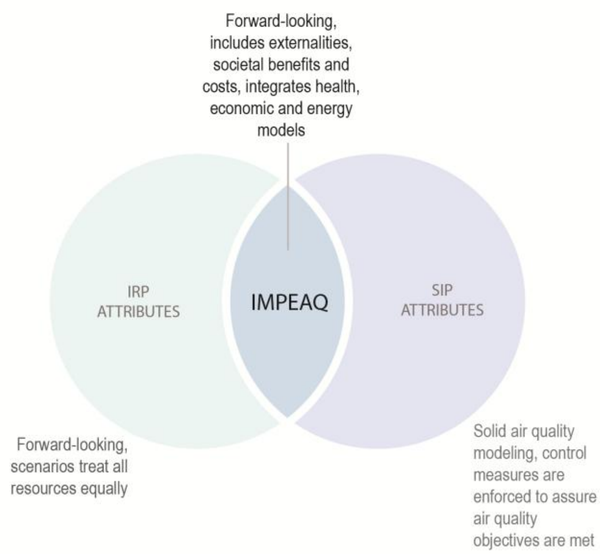
Conceptually, IMPEAQ is somewhat analogous for air quality agencies to the IRP processes conducted by or for state public service commissions in the energy sector. IMPEAQ is a state-led process that would create a comprehensive, forward-looking plan that evaluates the state's resources, carrying capacity of the airshed, and variables that influence that capacity, and determines what measures will be needed or sustained to provide clean air. Done right, IMPEAQ should address these key issues:

A. How clean does the state want its air to be and by when?
B. How can it regulate air quality the way that humans, animals, and plants experience the effects of air pollution, i.e., from a multi-pollutant perspective?
C. How can the state comply with Clean Air Act state implementation plan (SIP) requirements while bypassing their limitations?
D. How can costs be optimized while complying with environmental and energy system reliability requirements?

However, it is important to note that IRP as practiced today also has weaknesses. Specifically, it circumscribes its universe too narrowly: it does not, for example, consider factors or costs "external" to its immediate purposes – no matter how real or important they are to other key societal goods, such as public health, environmental protection, sustainability, or future economic competitiveness. IMPEAQ endeavors to introduce IRP-like thinking into air quality management, but also to broaden IRP's comprehensiveness and applicability to incorporate the power sector's extended impacts and opportunities.

As shown in Figure 1, IMPAEQ takes the best of both air quality and energy planning. Good air quality planning includes solid modeling and the development of enforceable control measures. A good IRP treats all resources (supply and demand side) equally and looks out over 10-15 years or longer. However, IRPs often do not include “externalities,” like public health and harm to the environment. If they do, it is often only for a limited set of variables or at default costs. Air quality plans often do not consider all resources (in this case, end of pipe, process changes, and root of pipe) that could be implemented to meet the required air quality objectives.

Figure 1. Relationship of IMPEAQ to IRP and SIP Attributes



A. How Clean and By When?

The process by which states develop air quality plans is a continuum.[9] Every five years, EPA must review the available scientific and public health data concerning a particular national ambient air quality standard (NAAQS)[10] and, based on its findings, determine whether to keep the standard at the existing level, revise it, or establish a separate secondary standard. Ambient air quality in each state is then compared to the NAAQS, and control measures are developed within three years of an EPA designation to demonstrate how the state will achieve the requisite air quality. This process is repeated for each of the six criteria pollutants, and separate

[9] Some have characterized the existing SIP-based process as a “do-loop,” including many state and EPA staff with whom we spoke while researching this topic, e.g., just as a state reaches attainment of a standard, it changes and the state has to “do it all over again.”

[10] We use NAAQS throughout as shorthand for all Clean Air Act programs, including National Emission Standards for Hazardous Air Pollutants (NESHAPs or HAPs), New Source Performance Standards (NSPS), and New Source Review (NSR). The latter three programs are also periodically revised by EPA, and states must adopt new or revise existing air quality plans to meet EPA’s revised requirements.

requirements have been or are being promulgated for hazardous and GHG pollutants. States may have their own locally applicable requirements as well, such as more stringent standards for certain pollutants, standards for noise and odor, and policies or requirements to reduce GHG emissions. Because this approach focuses on individual criteria pollutants, however, sources often face the confounding prospect of complying with multiple regulatory programs for individual pollutants and/or controlling multiple pollutants under individual regulatory programs.

Today, air quality programs are binary in character: if a state is in attainment of the NAAQS, the state only needs to show that its existing regulations are adequately protective and that the state will remain in attainment. If a state is in nonattainment, however, its air quality plans must address how the state will meet a particular NAAQS in three, five, or ten years, depending on the severity of its pollutant concentrations. What if, instead of looking at air as though it was differentiated by individual pollutants and disparate timeframes, states were encouraged to ask: how clean do we want our air to be and by when?

States know they have to meet today's NAAQS and applicable Maximum Achievable Control Technology (MACT) and GHG standards; these requirements establish a federal regulatory "floor." But might the approaches states have traditionally employed (i.e., pollutant-specific control measures) be different if they took into account the fact that future NAAQS and other Clean Air Act programs are likely to require further air quality improvements?[11] In other words, might states develop plans and implement actions to help prevent future nonattainment over the long term?

The answer, of course, would vary by state and local agency. One jurisdiction might identify how clean it wants its air to be in, say, 2020 or 2030, next determine the rate of air quality improvement needed to achieve this goal, and then decide the best ways to reduce emissions correspondingly. In doing so, it would proactively create and follow a "glide path" to cost-effectively avoiding nonattainment in the future. Another state might decide to limit its actions to only those steps required to comply with the federal regulatory floor and to take its chances on the imposition of more stringent Clean Air Act requirements in the future. State and local agencies would not approach these decisions lightly, given the difficulty of persuading public and corporate behavior to change. Capable, effective, visionary agency and policymaker leadership would also be essential to success. However, greater flexibility and the opportunity for increased state and local economic development, reduced health care costs, and improved air quality would comprise compelling additional reasons to pursue IMPEAQ.

[11] A highly probable outcome: NAAQS are revised every five years, and the NAAQS have almost never been made less protective of public health and the environment. NSPS are reviewed every eight years, and may be revised or amended (i.e., either made more stringent or applicable to sources with lower annual emissions). Maximum Achievable Control Technology standards for toxic air contaminants are reviewed every eight years to assess whether the initial technology-based standards adequately address risk.

B. Regulate Air Quality from a Multi-Pollutant Perspective

Humans, plants, animals, and the built environment experience the combined and cumulative effects of all pollutants. Certain pollutants have greater affects than others depending upon their concentrations and duration of exposure. We know the effects of acid rain on the environment and inanimate objects. The effects of high ozone levels are directed at humans, animals, and common agricultural and forest plant species. Fine particles may be embedded with toxic metals and affect humans acutely. Exposure to toxic compounds is common in today's society, and the accumulation of GHGs in the atmosphere is now having demonstrable effects.

The U.S. has made enormous progress improving air quality since the deadly 1948 Donora, Pennsylvania episode[12] and the eye- and throat-searing 1950s-era Los Angeles smog. Instrumentation and science about air pollution and its health effects have also advanced significantly. We have evolved from regulating air pollution by focusing on visible black smoke and soot – even collecting total suspended particulates in buckets – to using sophisticated monitors that continuously measure stack pollutant concentrations and Fourier-transform infrared-based instruments that sample entire air parcels and simultaneously measure the levels of all pollutants.

Yet, the way in which we plan for and regulate air quality has not evolved as fully or comprehensively as that of our scientific and public health knowledge. Control measures are evaluated based on their efficacy at reducing a single targeted pollutant within the timeframe required. States prepare separate plans for each pollutant, and these distinct plans are amended and revised over time, as EPA promulgates a new or revised NAAQS or to meet other requirements (e.g., regional haze and visibility protection, Prevention of Significant Deterioration [PSD], New Source Performance Standards [NSPS], or Title V operating permits).

Regulating air quality in a way that is consistent with the way we actually breathe air would mean selecting control measures not only on their ability to meet specific individual NAAQS, but on how well they reduce multiple pollutants (including hazardous air pollutants and GHGs), whether any pollutants may be inadvertently increased, and the costs involved.

Public health benchmarks would need to be incorporated as indicators of improved air quality, arguably bettering the process. After all, should not states be asking questions like, "What measures can achieve the greatest overall public health and welfare benefits at the lowest

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[12] In October 1948, an air inversion caused smog to flow and then concentrate in Donora, Pennsylvania, then a major steel producing city about 35 miles from Pittsburgh. Twenty people died directly, and thousands of the town's 14,000 residents were sickened. In 2008, the New York Times called the incident "one of the worst air pollution disasters in the nation's history". (Davis, Devra (2002). When Smoke Ran Like Water: Tales of Environmental Deception and the Battle Against Pollution. New York: Basic Books. See also Hamill, Sean D. "Unveiling a Museum, a Pennsylvania Town Remembers the Smog That Killed 20", *The New York Times*, November 1, 2008.)

cost?" Or, "What measures can best reduce overall morbidity and mortality by one-half over the next 10 or 20 years?"

C. Complying With Clean Air Act SIP Requirements While Bypassing Their Limitations

The IMPEAQ process would address current and expected future requirements from the four major air quality programs: NAAQS, NSPS, NESHAPS and NSR, *as well as* those associated with climate change, environmental justice, and local pollution hot spots. *None* of the latter programs are in a SIP. EPA designates areas across the United States as nonattainment if any monitored ambient air pollutant concentration exceeds its NAAQS. Nonattainment states are required to adopt and enforce measures to control such pollutants and must do so in accordance with the timelines required by the Clean Air Act.

> With IMPEAQ, we propose to consider all pollutants explicitly and simultaneously at the front-end of the process, proactively seeking a mix of measures that holistically and interdependently address multiple pollutants at once.

Traditionally, however, SIPs have been developed and completed for individual pollutants. Occasionally, control measures from one SIP are examined to ascertain their impact, if any, upon other SIPs. This is a complicated process precisely because the SIPs were generally designed in isolation from one another, usually with little thought about how control measures for different pollutants might interact. With IMPEAQ, we propose to consider all pollutants explicitly and simultaneously at the front-end of the process, proactively seeking a mix of measures that comprehensively and interdependently addresses multiple pollutants at once. Then, as required by EPA, appropriate parts of the IMPEAQ results could be submitted to meet SIP requirements or even for several SIPs.[13] In short, compliance with each SIP required of the state would be satisfied, but determining the measures necessary to do so would be accomplished in one, integrated IMPEAQ effort rather than through multiple, arduous, SIP processes for individual pollutants.

Note that IMPEAQ is fundamentally different from what many agencies may think about regarding multi-pollutant processes. Congress has considered a "multi-pollutant emissions bill" (e.g., the Carper "3-P" or "4-P" bills), and the Cross-State Air Pollution Rule that EPA proposed [14] requires reductions of NO_X and SO_2, which would also help to reduce $PM_{2.5}$ concentrations. Rather than first installing SO_2 controls and then later installing NO_X controls, it makes sense to

[13] For example, a state may have to demonstrate that its control measures will be effective to attaining a new or revised NAAQS and have to update its NSR rules in the same timeframe.

[14] The Cross-State Air Pollution Rule was remanded by the DC Circuit Court on August 21, 2012.

have electric power generators order and install all necessary equipment at the same time in order to minimize the amount of time that a plant is off-line. But these "multi-pollutant" reduction plans are *not* the same as IMPEAQ: in these Congressional and EPA actions, multi-pollutant reductions were analyzed *after* a decision had been made to install pollution controls on power plants.

Neither Congress nor EPA has asked the larger question: what are the most cost-effective means to improve air quality and public health? Market-based programs like cap-and-trade or emissions trading were implemented in conjunction with the requirement to install controls, to give power companies choices about how to meet the requirements. The question was not: what measures can reduce public health effects by 50% and meet all NAAQS in ten years? Instead, it was how many tons of SO_2 or NO_X can be removed by establishing a BACT-type emissions rate for all power plants, and what other measures could be adopted at the same time to help reduce costs? While the Congressional and EPA programs have been very effective, they did not arise through "multi-pollutant planning processes."

IMPEAQ starts from a premise that concurrently reducing multiple pollutants is cost-effective and can satisfy energy and environmental goals at the same time. The IMPEAQ process solves for the most cost-effective means to do so. As part of the process, air quality and energy regulators and stakeholders would consider a diverse mix of control measures, evaluate trade-offs, and then prioritize the measures to be adopted and implemented in the course of joint discussions. IMPEAQ, in effect, says that the choice of control measures is based on whatever policies are most cost-effective to meet public health and air quality goals, not what are the costs and benefits of a particular policy after the control measures have been selected.

IMPEAQ's process *may* result in measures that require additional equipment to be installed on power plant stacks, but, more likely, IMPEAQ's process would also emphasize measures based on actions that do not occur at the stack, whose effects drive the type, location, and quantity of emissions reduced. Demand side programs, like energy efficiency and demand response, and supply-side policies, like combined heat and power (CHP) and renewable energy generation, would be evaluated equally with traditional means of reducing emissions, like end-of-pipe control technologies. IMPEAQ applies the gold standard from IRP and electricity planning processes – treat all resources equally – to the environmental context. While IMPEAQ itself is a new concept, a hint of what the IMPEAQ process would entail can be gleaned from over 30 state and dozens of local climate change action plans. In these plans, the analysis typically optimizes for greenhouse gas reductions. In almost every case, energy efficiency measures consistently ranked in the top ten measures, if not the very top measure, to cost-effectively reduce greenhouse gas emissions. Applying the same concepts to also include criteria and toxic air pollutants, IMPEAQ's results would be ranked by the ability of measures to reduce public health impacts and to meet criteria, toxic, and greenhouse gas pollutant reduction requirements and goals.

Section 110 of the Clean Air Act describes the requirements and procedures that a state must complete once EPA promulgates a NAAQS. The obligation to complete a plan and the timing by which it must be adopted are mandatory. States and EPA can be sued (and have been) to compel plans to be completed. EPA also has several escalating options that can be applied if a state fails to submit or implement a plan or if its plan is inadequate. These options range from emission offsets to withholding highway funding to imposing a federal implementation plan (FIP).

The Clean Air Act does not restrict states to developing air quality plans that only address one pollutant or that only include measures to reduce a single pollutant.

However, the Clean Air Act does not restrict states to developing air quality plans that *only* address one pollutant or that *only* include measures to reduce a single pollutant. Developing a comprehensive plan that harmonizes strategies among all pollutants can also satisfy SIP requirements.[15] Rather than completing SIPs for individual pollutants or for individual sources and evaluating how control measures from one SIP may impede or help attainment for other pollutants, IMPEAQ would consider all pollutants simultaneously. Following this, particular measures identified by IMPEAQ that satisfy EPA-mandated reduction requirements to attain specific single-pollutant objectives can be incorporated into a SIP. Simply put, one IMPEAQ process could satisfy several SIPs and concurrently reduce toxic and GHG emissions, at least cost and with minimum impact to energy and other systems.

Two influential bodies have recommended that EPA enable and encourage states to develop "multi-pollutant plans."[16] In 2004, the National Research Council of the National Academies of Science (NAS) published "Air Quality Management in the United States."[17] This comprehensive assessment identified five major recommendations for EPA to consider and adopt. Among them were to "*transform the SIP process into a more dynamic and collaborative performance-*

[15] This outlook, in fact, was one of the key drivers in the 2009 EPA multi-pollutant pilots in New York, North Carolina and St. Louis, and the 2010 Clean Air Plan developed by the Bay Area Air Quality Management District. In addition, technologies are being developed to capture multiple pollutants and use CO_2 at the industrial and power plant source level. Two examples are Calera (http://calera.com/index.php/technology/technology_vision/) and a process developed at the University of Wyoming (http://www.uwyo.edu/esm/faculty-and-staff/reddy/kj%20reddy_1.pdf). Both are designed to be more effective and less expensive than carbon capture and sequestration.

[16] As will be discussed in section 3, we believe a more relevant reference and template for the process described in this paper is the integrated resource plan (IRP) used in the electric and gas utility sectors. Based on our background discussion with many state and EPA air regulators, we believe one barrier to the development of an "air quality IRP" is that "multi-pollutant plans" typically connote "multi-pollutant SIPs". That is *not* what we refer to here. In addition, through optimization modeling and/or systems dynamics modeling, IMPEAQ could incorporate – rather than to relegate to "externality" status – important non-air-quality considerations, such as electric system reliability.

[17] National Research Council, *Ibid*

oriented, multi-pollutant air quality management plan (AQMP) process" and *"develop an integrated program for criteria pollutants and hazardous air pollutants".*[18]

In 2010, the Clean Air Act Advisory Committee (CAAAC) developed a framework for a multi-pollutant strategy.[19] The CAAAC's objectives were to align four major CAA programs: NESHAPS, NSPS, NAAQS, and NSR and to coordinate – for the affected sources of pollution – the timing and obligations associated with these programs. CAAAC noted, *"The Clean Air Act – read according to its express terms and without much of the intervening interpretative gloss of the past four decades – provides sufficient flexibility to achieve these objectives…."*

The NAS and CAAAC recommendations anticipate, and this paper explicitly posits, that done correctly along the lines of an "air quality IRP," states can develop comprehensive plans that meet existing NAAQS, as well as anticipate future, more stringent NAAQS, HAPs, and GHG reduction requirements. In other words, IMPEAQ would identify all measures needed to meet long-term air quality goals.[20]Each time a NAAQS, NSPS, or NESHAP is revised by EPA, the state would identify, assign, and/or add appropriate elements from its IMPEAQ and incorporate them into the required SIP as needed for EPA approval. Unlike IRP as practiced in the power sector, however, IMPEAQ would explicitly seek to include "externalities" in air quality decisions, e.g., societal benefits and costs associated with the adoption and implementation of air quality control measures.

D. How to Optimize Costs while Complying with Energy Reliability and Environmental Requirements

Economic models conclude that the costs to achieve a particular environmental end point are lower when the control measures reduce several pollutants at the same time and when both demand side measures and end of pipe measures are applied. For example, modeling completed by the Bay Area Air Quality Management District (BAAQMD) for its 2010 Clean Air Plan indicated that public health benefits and reduced damages from climate change in the range of $270 million to $1.5 billion per year could be achieved from a suite of 55 control measures that would jointly reduce criteria, toxic, and GHG pollutants.[21]

[18] National Research Council, *Ibid*, recommendations three and four.

[19] Clean Air Act Advisory Committee, Economic Incentives and Regulatory Innovation Subcommittee, "A Conceptual Framework for a Source-wide Multi-pollutant Strategy", September 2010. CAAAC formally advises EPA on air quality programs and regulatory standards.

[20] Like an IRP, we would expect that states would revise and update their IMPEAQ analyses from time to time. "All measures" would reflect a snapshot in time.

[21] Bay Area Air Quality Management District, *2010 Clean Air Plan,* Approved by BAAQMD Board September 15, 2010.

It is important to consider the costs avoided by a multi-pollutant air quality plan. A large investment to install controls to reduce one pollutant may be partially or fully stranded if an emission standard changes or a new standard is issued that requires control of another pollutant. For example, Public Service Company of New Hampshire (PSNH) received approval to recover costs from spending over $430 million on new emissions controls at its Merrimack Station, the largest fossil-fuel fired plant in the state. The cost of these emissions controls was reflected in the plant's higher operating costs; PSNH's energy service rates rose 13%.[22] Under the least-cost economic dispatch of generators practiced by the region's independent system operator, the plant's higher costs compromised its dispatch order. The combination of its higher hourly costs and current low natural gas prices shifted Merrimack Station's operation from running as a base-loaded plant to operating a summer peaking plant. As a result, ratepayers are paying more than they otherwise would have to recover emissions control costs at a plant that now operates comparatively little.

Work by J. Bollen (2009) using the GAINS model demonstrates that costs to reduce public health risk 50% over 20 years can be reduced by one-third when the control measures include energy efficiency, combined heat and power, *and* end of pipe controls, as compared to *only* end of pipe controls.[23] EPA's regulatory impact analysis for the mercury MATS similarly showed that the costs of meeting the mercury standard were $3-12 billion lower when energy efficiency was an integral part of the control strategy, and that emissions of SO_2, NO_X, and CO_2 were also lower.[24] Another EPA analysis performed for the cement industry indicated that compliance costs to meet NSPS and NESHAPs would be lower and provide greater environmental benefits if the various regulations were synchronized.[25]

In addition, two major utilities recently conducted IRP analyses of their future resource needs and costs, with various assumptions about future environment programs and risks. Xcel Energy's Minnesota affiliate found that a scenario maximizing the development of wind resources had similar costs to the scenario that relied on the continued use of its existing coal-dominated generation, but that the wind scenario reduced risk, uncertainty, and exposure from costs and requirements associated with future air pollution standards and was significantly less expensive if requirements to reduce GHG emissions were imposed.[26] The Tennessee Valley Authority

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[22] NH Public Utilities Commission Order No. 25346 in Docket No. DE 11-250 dated April 12, 2012 authorized PSNH to establish an Energy Service rate at 7.77 cents per kWh and a temporary Scrubber cost recovery rate at 0.98 cents per kWh for a combined Energy Service rate of 8.75 cents per kWh, effective April 16, 2012.

[23] J. Bollen, et. al., Local Air Pollution and Global Climate Change: A Combined Cost-Benefit Analysis, *Resource and Energy Economics,* v. 31, 2009, pp. 161-181.

[24] U.S. EPA, *Regulatory Impact of the Proposed Toxics Rule*, March 2011, Final Report, Chapter 8.

[25] Matthew Witosky, U.S. EPA Office of Air Quality Planning and Standards, *Sector-based Multi-pollutant Approaches for Stationary Sources*, presented to Clean Air Act Advisory Committee, May 26, 2010, Washington, DC

[26] Betsy Engelking, Xcel Energy, Presentation to NARUC Energy Efficiency and Renewable Energy Committee, February 2011, Washington, DC.

(TVA) IRP found that a diverse resource mix that included more investment in energy efficiency and renewable energy represented both the lowest cost and the lowest risk to the utility.[27] TVA's conclusions are consistent with a CERES report that analyzed the costs and risks associated with various resources to provide stable and reliable electricity. CERES found that increased energy efficiency was the most cost-effective resource and had the lowest composite risk of new energy resources.[28]

The IMPEAQ process that we envision is an air quality planning process that builds upon the best components of an IRP and also incorporates environmental, energy, and economic externalities that are not typically included in an IRP. Including externalities and their influence upon the cost-effectiveness of control measures – and whether and how control measures may have unintended consequences – helps to meet both air regulators' goals to attain and maintain compliance with NAAQS and other requirements of the Act, as well as energy regulators' goals to assure reliable and affordable electric and gas service.

The remaining sections of this paper elaborate on the IMPEAQ idea. Section 3 describes what we mean by an air quality plan, the differences between an air quality plan and a SIP, why more air quality plans have not been done, and the barriers to doing so. Section 4 further characterizes the IMPEAQ concept and its framework. Section 5 describes how IMPEAQ can address the barriers identified in Section 3. Section 6 describes the IMPEAQ process in schematic terms. Section 7 provides conclusions and recommendations for next steps in how to operationalize the IMPEAQ process.

While this paper covers many elements of a new air quality planning process, its purpose is to break new ground, not to be a defining document for states to develop multi-pollutant air quality plans. Our goal is to provide a conceptual framework that state and local agencies, EPA, regulated entities, environmental advocates, and the public can understand, appreciate, review, critique, and improve. We hope to apply feedback from a diverse mix of state, environmental, utility, consumer, and EPA experts to advance this concept and broaden its audience. The purpose of this paper is to serve as a framing document in order to help initiate constructive discussions. Its ultimate test will come when one or more states actually apply IMPEAQ to their air quality and energy planning, providing proof-of-concept and serving as an example for other jurisdictions to adapt to their own needs.

[27] Tennessee Valley Authority (TVA), TVA's Environmental and Energy Future, 2011. http://www.tva.com/environment/reports/irp/pdf/Final_IRP_complete.pdf

[28] CERES, "Practicing Risk-Aware Electricity Regulation: What Every State Regulator Needs to Know", April 2012 (see figures ES-3 and ES-4, pages 8-9)

3. Problem Definition

A. Integrated Multi-Pollutant Planning for Energy and Air Quality (IMPEAQ)

The term air quality management plan can have multiple meanings. States and EPA have used different terms to describe or define what they mean by a multi-pollutant plan. Further confusion occurs when the terms air quality management plan (AQMP) and SIP are interchangeably used, because an AQMP can have multiple meanings. An AQMP is not necessarily a SIP. Here, we define and describe IMPEAQ as follows:

- A comprehensive, forward-looking approach to planning that transcends but anticipates current and future NAAQS, NSPS, NESHAP, and NSR program standards and revisions. Planning also addresses greenhouse gas emissions, environmental justice, and locally important air quality and energy programs and policies (which are not typically parts of a SIP). We recommend a minimum of 10, and preferably 20, years as a planning timeframe;
- The equivalent of an "air quality IRP" inclusive of known, important "externalities;"[29]
- A process that is led by state and local air quality regulators but which also involves other key participants as required to determine criteria for optimal paths to meet the state's needs;
- A process that makes use of the sophisticated optimization modeling[30] and/or systems dynamics[31] tools now available to policymakers.[32] These techniques employ specific

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[29] Identifying and quantifying the value of externalities today is a mixed picture. Several externalities, such as public health burden (mortality and morbidity), agriculture and forest damages, fish kills and damages to the built environment, have well-documented and robust data. Others, such as potential future damages from climate change, are based on estimates. In any event, we know today that the correct values for these externalities are *not* zero, and the societal costs related to externalities should be accounted for in regulatory decision making.

[30] Optimization modeling is used to determine alternatives with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. (In comparison, maximization means trying to attain the highest or maximum result or outcome without regard to cost or expense.) Practice of optimization is restricted by the lack of full information, and the lack of time to evaluate what information is available. In computer simulation modeling of business problems, optimization is achieved usually by using linear programming techniques of operations research. (See http://www.businessdictionary.com/definition/optimization.html#ixzz1yXZ4xn17)

[31] System dynamics is an approach to understanding the behavior of complex systems over time. It deals with internal feedback loops and time delays that affect the behavior of the entire system. What makes using system dynamics different from other approaches to studying complex systems is the use of feedback loops and stocks and flows. (See en.wikipedia.org/wiki/System_dynamics)

[32] See, for example, Zeng et al, *A Review on Optimization Modeling of Energy Systems Planning and GHG Emission Mitigation under Uncertainty*, 2011. This paper is available at http://www.mdpi.com/1996-1073/4/10/1624.

mathematical and computer-based techniques to help provide insight on complicated problems and systems;[33]

- An approach that addresses the threshold questions posed in Section 2: How clean does the jurisdiction want the air and by when? How do we regulate air quality in the multi-pollutant way we breathe air? How do we comply with SIP requirements while respecting their limitations? How to do so optimally with respect to energy reliability and cost?[34]

B. Differences between IMPEAQ and SIPs

A SIP is a collection of policies, procedures, and regulations that a state uses to demonstrate how it will achieve and maintain compliance with the four key Clean Air Act programs: NAAQS, NSPS, NESHAP, and NSR. SIPs submitted to EPA must be legally defensible. The IMPEAQ embeds sound technical analysis into a framework that characterizes all air quality influences. Consider IMPEAQ as an "umbrella" or "omnibus" plan from which relevant pieces can be extracted to meet single-pollutant or program-specific SIP requirements. The IMPEAQ may contain dozens of control measures across all sectors. Note that it is unlikely that the results of the IMPEAQ process will be an equal apportionment of air pollutant reductions among sectors. The least cost controls are likely to be concentrated in certain sectors, and "sector fairness" is not a criterion to decide what reduction burden should be shouldered by a particular sector. We believe that the best process will achieve significant, targeted air quality improvements at the lowest societal cost.

To demonstrate compliance with current and future Clean Air Act requirements, a state would select from the comprehensive IMPEAQ analysis a subset of control measures that, when implemented, would enforceably reduce pollution. The state would then include those measures in a specific SIP. The IMPEAQ itself could even address some air quality issues of concern to the state that would never be included in a SIP.

a. Why haven't IMPEAQ concepts already been implemented?

A fair question to ask is: if the IMPEAQ approach is so good, and is consistent with the recommendations of such august and diverse bodies as the National Academies of Science and the Clean Air Act Advisory Committee, why have they not been done already? Outside of the

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[33] Christopher V. Jones, Visualization and Optimization, available at http://www.informs.org/Pubs/ITORMS/Archive/Volume-2/No.-1-Jones.

[34] How costs are defined is clearly an important issue (e.g., emission reduction costs, lifecycle costs, various cost tests, externalities and/or other criteria to be considered in selecting solutions that energy IRP's don't typically employ, etc.). In the interests of explaining the IMPEAQ concept, the issue of defining cost is not explicitly addressed at this time. Further, in implementing an IMPEAQ approach, states' judgment regarding costs can and should be tailored into the process.

BAAQMD 2010 Clean Air Plan, there are few examples of planning on a multi-pollutant basis. Other efforts to develop multi-pollutant plans recently have been initiated,[35] but progress has been slow. EPA's willingness and ability to accept such plans is unclear, and EPA's own approaches to energy – including energy efficiency and renewable energy – continues to evolve. With the existing sample size so limited and progress so slow elsewhere, is it wise to consider doing such a plan?

Many barriers exist that have prevented and precluded states and EPA from developing multi-pollutant plans. They include institutional, structural, and technical obstacles. They are described further below.[36]

b. Barriers to multi-pollutant planning

We identify barriers to developing an IMPEAQ as institutional, structural, and technical. Other barriers may exist in addition to those described below, but these are the chief ones raised to date in the context of multi-pollutant air quality planning.

Institutional

Resources: The Clean Air Act requires states to develop SIPs. How can a state consider an IMPEAQ, which is optional, when it is also legally obligated to complete SIPs and is subject to federal sanctions if it does not do so? States may reasonably be concerned that any time taken away from doing a SIP may expose the state to litigation or potential sanctions if its SIPs are late or deemed inadequate.[37]

Single pollutant regulatory focus: Implementation of the Clean Air Act has evolved along single pollutant paths. Required indicators of progress toward meeting a NAAQS also focus on individual pollutants. EPA's Ozone Advance program strives to provide incentives for states to take early actions to reduce ozone pre-cursors. This is an important step forward but still focuses planning on a single NAAQS. With the $PM_{2.5}$ NAAQS also scheduled for revision soon, an analogous "Multi-Pollutant Advance" program by EPA would help states identify and implement early actions to reduce both $PM_{2.5}$ and ozone and their pre-cursors.

EPA's multi-pollutant planning is not IMPEAQ: EPA has responded to recommendations to adopt multi-pollutant approaches. Work completed by OAQPS on cement industry regulations to

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[35] In New York State, North Carolina, Maryland, and St. Louis, for example.

[36] See also generally: Weiss, L.; Manion, M.; Kleiman, G.; and James, C. "*Building Momentum for Integrated Multi-pollutant Planning: Northeast States Perspective*", Environmental Management Journal of the Air and Waste Management Association, May 2007, pp 25-29. (Weiss, Manion and Kleiman- NESCAUM; James- Connecticut DEP)

[37] As envisioned, the comprehensive IMPEAQ will ultimately provide a superior compliance alternative, but states will face need to make an upfront investment, particularly in the staff time necessary to initiate it, and especially until the first few IMPEAQ-derived SIPs are completed and approved by EPA.

combine NSPS and NESHAPS requirements is a positive step. Even better would be for EPA to embrace IMPEAQ and state processes, like those of Maryland and New York, as templates for other agencies to follow and to approve control measures developed through these multi-pollutant processes as part of state or local SIPs.

Sustaining progress: As noted earlier, capable, effective, visionary agency, and policymaker leadership is essential to successful paradigm shifts like moving from today's regulatory practices to optimized, comprehensively integrated, multi-pollutant planning like IMPEAQ. Because leaders change over time, how can progress be sustained over the long-term?

Structural

Inertia: States and EPA have been very successful at reducing criteria and toxic pollutants over the past 40-50 years. Yet, 50% of Americans live in areas that still fail to attain one or more of the NAAQS, and United States air quality standards for fine particles and ozone are less protective than levels recommended by EPA's CASAC and the guidelines established by the WHO.[38]

Resource constraints: EPA, state, and local air quality agency budgets are tight, and many have been reduced in recent years. IMPEAQ requires additional work upfront, which may mean temporarily shifting or reprioritizing resources away from other programs to complete the IMPEAQ process.

Disbelief or misinformation: A process like IMPEAQ looks at all plausible options, including, for instance, energy efficiency. However, some regulators maintain the perception that energy efficiency programs in particular do not produce significant energy savings, or if energy savings do occur, that a "rebound effect" on the part of energy users reduces any real savings on a net basis.

Short-term thinking: Some policy makers would acknowledge that multi-pollutant planning and energy efficiency work, but their benefits accumulate over time and thus likely accrue to a later administration. A state's current governor may not receive any credit for the benefits that multi-pollutant planning engenders, so resources may instead be diverted to activities that have more immediate or visible benefits.

[38] EPA, *Summary Population Exposure Report*, March 30, 2012. Retrieved from http://www.epa.gov/airquality/greenbook/popexp.html. EPA's report indicates 154,454,000 people live in an area that is in nonattainment for at least one of the NAAQS; the U.S. Census Bureau indicates that the U.S. population as of July 2011 was 311,591,917.

Technical

Science: The value of multi-pollutant approaches may be underestimated because limited research is available on the synergistic effects of air pollutants. Some evidence exists that adverse effects can result from simultaneous exposure to multiple pollutants at levels that would not be harmful if any one pollutant was considered in isolation.[39]

Tools are needed to assess efficacy and costs of control measures: Much of the work done on SIPs is grounded or substantiated by the use of complex computer modeling. Such mature modeling does not yet exist for AQMP. Is a multi-pollutant model a pre-condition to completing an AQMP?

Imprecision: All models have some degree of imprecision. Existing EPA models were designed to assess the regional effects of policies on the power sector. Some were developed before electricity restructuring and reflect a world dominated by large, utility-owned central power stations. How can the benefits of energy efficiency (EE), renewable energy (RE), CHP and demand response (DR) be assessed more easily and precisely given today's new market structures and further fundamental changes underway in the industry?

Assessing and crediting policy benefits: A state with good energy efficiency or renewable energy programs may influence generation in another state. Current EPA policy and guidance permits a state to take credit only for the EE or RE benefits that occur within its boundaries. This may be appropriate for local pollutants, but for GHGs, which also have global impacts, how should EE and RE investments that influence generation in another state be accounted for and credited?[40]

Compliance with end-of-pipe control measures is easy to determine: Continuous emissions monitors and other instrumentation facilitate nearly instantaneous compliance determinations. By contrast, EE and RE impacts are not yet as readily ascertainable.

4. Integrated, Multi-pollutant Planning for Energy and Air Quality (IMPEAQ)

IMPEAQ is a process, convened by air regulators, that addresses the four key issues posed in Section 2:

- How clean should the air be and by when?

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[39] See research into synergistic affects of pollutants and toxic substances, for example: Washington Department of Labor and Industries, "Understanding Toxic Substances", accessed at http://www.lni.wa.gov/wisha/p-ts/pdfs/toxicsubstances.pdf

[40] Note that for determining offsets for new or modified air pollution sources, emissions reductions that occur in another state can be credited, assuming the reductions are proximate and directionally correct, i.e., usually from an adjacent state and in a state upwind of the state seeking to use the offsets.

- How to regulate air quality from a multi-pollutant perspective?
- How to avoid but comply with laborious SIP requirements?
- How to optimize costs while complying with energy reliability and environmental requirements?

We think of IMPEAQ as a new model for air quality planning but emphasize that the term "model" as used here reflects a conceptual framework. Although significant initial effort will be required to develop, adapt, and/or pilot the system dynamics or optimization model(s) and databases necessary to conduct IMPEAQ, we neither believe nor recommend that new technical air quality or economic models need to be developed. In fact, many excellent component tools already exist or are nearing completion. Northeast States for Coordinated Air Use Management's (NESCAUM) Multi-pollutant Policy Analysis Framework (MPAF) represents significant progress, for example.[41] The BAAQMD developed its own Multi-Pollutant Evaluation Method in-house to evaluate costs and the efficacy of various control measures. -The International Institute for Applied Systems Analysis (IIASA) developed the GAINS model, which solves for the lowest cost measures that jointly reduce pollutants.[42] The Electric Power Research Institute (EPRI) and the Eastern Regional Technical Advisory Committee (ERTAC) are developing new models that will, among other things, account more precisely for energy efficiency and renewable energy resources.[43] China has completed the initial development of a technical model that evaluates the costs and efficacy of co-controlling criteria pollutants and carbon dioxide.[44]

There are many good models and tools that air regulators can draw upon to help them evaluate how selected control measures would improve air quality and what their costs would be. However, using each of the different types of models – air quality, energy, and economic – in a comprehensive and integrated fashion would help the regulators identify, prioritize, and implement control measures that are best suited to meet a state's air quality objectives. Inclusion of the energy component means that the influence of selected control measures on energy costs and reliability can also be assessed and considered in concert with the state's energy regulators. There is no *single* model or tool available today to conduct such a comprehensive analysis, but regulators do not need to wait for such a model or tool to be completed or matured in order to conduct the type of multi-pollutant analysis we describe.

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[41] See: http://www.nescaum.org/activities/projects-in-progress/multi-pollutant-planning/

[42] The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS), International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria http://gains.iiasa.ac.at/models/index.html

[43] Electric Power Research Institute (EPRI), PRISM Model. http://mydocs.epri.com/docs/SummerSeminar10/Presentations/2_Hannegan-EPRIFINAL.pdf

[44] HU Tao, *Co-control of Air Pollutants and GHG*, presented March 14, 2012, Woodrow Wilson International Center, Washington, DC. http://www.wilsoncenter.org/sites/default/files/Hu%20Tao%20on%20co-benefits.pdf

IMPEAQ is the umbrella process from which specific program elements are selected to meet current and future SIP requirements. Employing the above tools in a comprehensive optimization model would include the following key elements:

- *Long-term view*: Given the state air shed's carrying capacity, what quantities of pollutants can be emitted over what time period and still make it possible to attain and sustain compliance with applicable Clean Air Act and state regulatory requirements and goals?
- *Reduced risks to public health and the environment*: The benchmark public health effects and environmental impacts that are to be reduced and over a particular time period;
- *Cost-effectiveness*: Rank order of control measures based on effectiveness to jointly reduce criteria, toxic, and GHG pollutants to achieve the Clean Air Act, public health, and environmental objectives;
- *Use existing technical tools:* Draw upon and use technical tools and economic, environmental, and energy models (such as those highlighted above) to inform the IMPEAQ;
- *Elicit input and garner support from others*: Air regulators invite participation and input from a variety of stakeholders and experts, particularly from within the energy sector, based on specific requirements and needs;
- *IMPEAQ is a process, not an outcome*: Like a SIP, IMPEAQ would be revisited from time to time. Unlike SIPs, and an improvement upon them, the multi-pollutant process would be iterated. A state or local agency could transition from the traditional SIP process to the IMPEAQ process, perhaps starting by looking at two pollutants together (such as ozone and $PM_{2.5}$)and then incorporating other criteria, toxic, and GHG pollutants. Alternatively, a state's IMPEAQ might first focus on a metropolitan area before being expanded to an entire state; and
- *Timing*: Developing an IMPEAQ at the same time that a utility or state is preparing an IRP would serve multiple objectives and efficiently use resources and analytical tools. Utilities and regional transmission organizations routinely conduct electricity dispatch modeling. Input from state air regulators on environmental variables would improve the IRP, and the results of the IRP would help inform the IMPEAQ.

Addressing the Four Issues: How Clean and By When? How to Regulate Air Quality from a Multi-Pollutant Perspective; How to Comply with SIP Requirements While Bypassing Their Limitations; and How to Optimize Costs while Complying with Energy Reliability and Environmental Requirements.

Air regulators are facile at adopting pollutant-by-pollutant regulations that clean the air to meet existing standards. In the Introduction we asked, what if the question was framed differently? That is, rather than thinking about designing control measures needed to meet a specific NAAQS, air regulators evaluate a suite of measures that could meet existing and anticipated new standards. How would this re-framing change the planning process? And, how might we accomplish the reframing?

Reframing the planning process would emphasize two key objectives: First, using public health as a benchmark, determine the desired reduction in public health risk and environmental exposure. Second, evaluate control measures on the basis of both their efficacy to reduce pollution and their cost effectiveness – in essence, move up a cost curve that has been optimized to meet multiple pollutant reduction and economic goals. An example of the process to complete the reframing could proceed as follows.

Reducing public health risk and sustaining progress improving air quality over time is akin to an air quality IRP, with the clear inclusion of societal benefits and costs. Subject, of course, to the floor of current and future federal air quality requirements, air regulators could ask questions like:

- "How clean do we want the air in our state to be by a given date, at what rate of improvement should it be accomplished, and what resources are needed to reach this goal?"
- "If we[45] want to reduce public health exposure to air pollutants in our area 50% by 2030, what measures do we need to adopt in order to reach that goal?"[46]
- "We know that EPA will be promulgating new NAAQS for ozone and for $PM_{2.5}$ in the 2013-2014 timeframe and that this process will recur in the 2018-2020 timeframe. Knowing that NAAQS have never been revised to be *less* protective, what measures should we consider now in order to meet prospective 2013-2014 ozone and $PM_{2.5}$ NAAQS (and thus avoid nonattainment designation), and how many tons of pollutants

[45] In these examples, "we" refers to a state.

[46] Public health measures have a rich data set of costs and effects. Health burden is not the only societal cost (and, as we continue to learn more about the risks and costs associated with water impacts under climate change scenarios, it may not be the most expensive). However, concern about public health is what drove people and government to take action over air pollution decades ago, and EPA regulations continue to emphasize the value to public health from newly proposed or amended regulations.

> need to be removed beyond this timeframe in anticipation of the adoption of even more stringent NAAQS toward the end of the decade?"

It is certainly likely that EPA will revise either or possibly both the ozone and PM standards to make them more protective beyond 2014. Even if EPA were to decide not change the NAAQS in 2018, a change five years later is becomes even more likely. This is because our knowledge of science and measuring effects continues to improve and because current ozone and $PM_{2.5}$ NAAQS are less stringent than levels already recommended by EPA's Science Advisory Board and the World Health Organization. Also, $PM_{2.5}$ is often a surrogate for air toxics and black carbon, and ozone is a short-term climate forcer. Any additional reductions in those pollutants would have complimentary benefits for reducing pollutants that contribute to climate change and other air quality problems

A variation on this first approach would be to consider the long-term planning around a single pollutant, like ozone. Today, a state with an ozone design value of 69 parts per billion (ppb) is considered in attainment of the 2008 ozone standard of 75 ppb. However, in September 2011 EPA proposed to revise the ozone standard to 70 ppb, and the Clean Air Scientific Advisory Committee (CASAC) has recommended that EPA consider lowering it to between 60 and 70 ppb. While it is not certain that EPA will propose to tighten the ozone standard during its next revision, it is equally risky to assume that the standard will not be changed. States can help manage this risk and uncertainty through efforts to further improve air quality in advance. Doing so would facilitate the effort to prepare an ozone SIP when new designations are made by EPA. Areas considered marginal today, for instance might be able to entirely avoid being designated as non-attainment in the future.

Given this fact, states could plan now to determine how to meet what is likely to be a more stringent NAAQS and thus avoid any economic consequences of being designated as a nonattainment area. This, in fact, is precisely the tack EPA is taking in promoting to states its new Ozone Advance program. A review of three-year averages of ozone ambient monitoring data reflects that there are many areas of the U.S. that currently attain the 75 ppb NAAQS but whose design value is in the 67-69 ppb range. These areas would be required to develop attainment plans should EPA propose an ozone NAAQS lower than 70 ppb. The group includes states or metropolitan areas that have not previously had to complete ozone SIPs, so regulators may have a steeper learning curve. A state that follows the IMPEAQ process is more likely to implement measures that reduce ozone precursors and other pollutants proactively, enabling it to meet revised ozone NAAQS, as well as future revisions to other Clean Air Act programs.

Figure 2. U.S. Counties at Risk of Being Designated Nonattainment for Ozone[47]

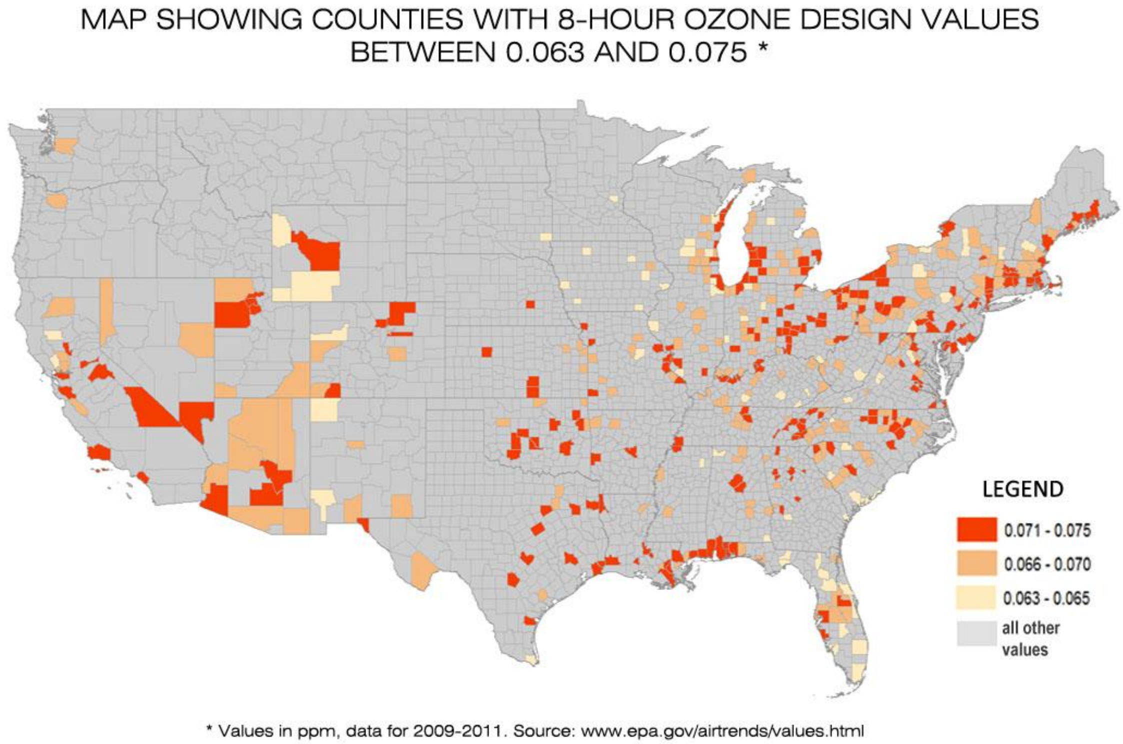

Figure 2 shows the counties in the United States whose ozone design value ranges from 63 to 75 parts per billion. These counties would be areas where application of IMPEAQ could help the county to meet the current ozone standard as well as future revisions.

A second element of a reframed process would be to have air regulators engage with their public service commission colleagues. States know they have to comply with the NAAQS.[48] During such meetings, air regulators would emphasize that meeting NAAQS is mandatory, just as meeting reliability standards is mandatory for their commission colleagues. Considering the issues of "how clean and when" and "avoiding SIP travails," an air regulator might discuss the state's existing energy efficiency programs with commission staff. Both agencies are familiar with multiple ways to meet objectives and recognize that some ways cost less than others.

The air regulators could recommend that, if more energy savings can be made, such savings would help to avoid a future nonattainment designation. Such energy savings would provide a more stable and cost-effective way for the state to meet reliability standards, deferring or

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[47] U.S. EPA, Office of Air Quality Planning and Standards. Data are for 2011, do not represent final agency action and are subject to revision based on quality assurance and quality control procedures.

[48] As with our shorthand for "state" above, "NAAQS" is shorthand for all four of the major Clean Air Act programs: NAAQS, NESHAP, NSR and NSPS.

avoiding the need to build new generation and higher electricity rates. Another example would be for the air regulators to work with their public service commission colleagues to answer the question, "What are the most cost-effective resources our state could acquire to meet future electricity load growth, stabilize electricity prices, manage risk, and reduce volatility?" These are but two examples in applying an overall optimization model to joint air quality and energy issues.

Air regulators have some discretion as to what measures are adopted to meet NAAQS. The discussions with public service commission (PSC) staff would not be about the cost-effectiveness of energy efficiency measures per se (which is typically the jurisdiction of the PSC) but would focus on how energy efficiency measures can help in meeting the health-based endpoints required by the Clean Air Act. During these discussions, the PSC would learn that, without additional energy efficiency programs, the air regulators will likely have to impose more costly end of pipe measures at their disposal to reduce pollution from power sector sources and/or on other sources. For example, people may have to get their cars inspected or additional controls may be required on industrial sources and/or imposed at lower pollution thresholds. Absent direct cooperation with a PSC, however, air regulators could make these same points by intervening in rate cases or pre-construction financing approval cases for new generation.

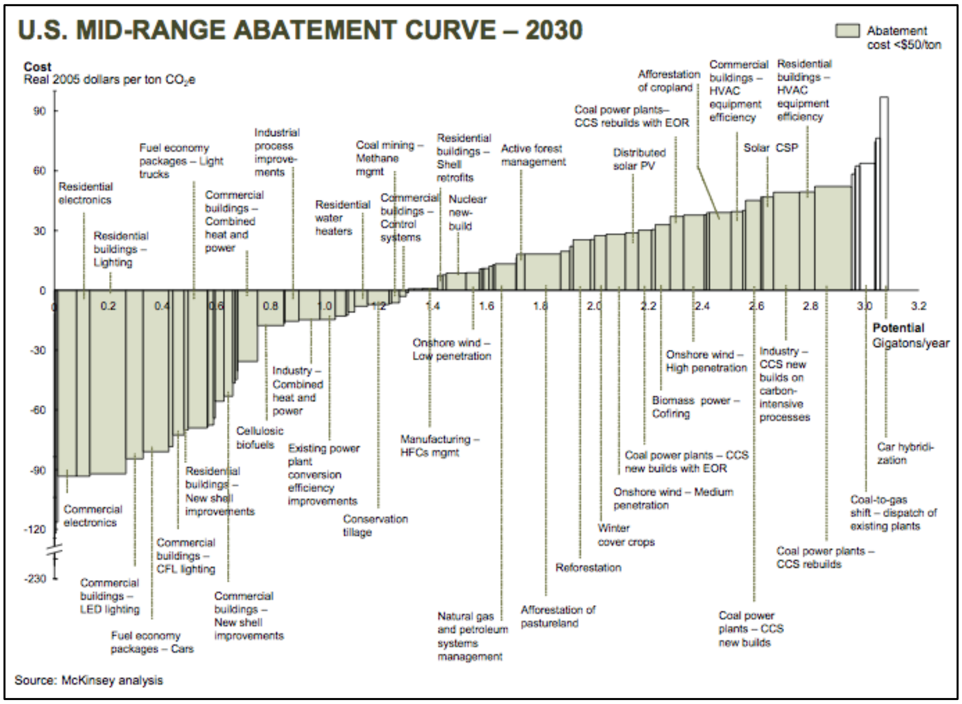
IMPEAQ's Hallmark: Developing cost-curve analogues for air quality (i.e., "emission reduction opportunity curves") and applying optimization modeling

Answering the "how clean and by when question" requires a thorough analysis of available control measures to assess their ability to improve air quality and determine their cost-effectiveness. In such analyses, available options are typically identified, assessed, and prioritized with the assistance of marginal abatement cost curves (often referred to as "MAC curves" or simply "cost curves"). Cost curves are so named because they provide a concise graphical representation of an underlying database of available measures, sorted by cost and effectiveness. Though often referred to simply as "cost curves" in conversation, the use of this term generally includes reference to the comprehensive database of measures, not simply the graphical illustration. Regrettably, deliberate, comprehensive approaches of this nature are infrequently applied in air quality management today.[49]

McKinsey and Company developed a well-known cost curve (see Figure 3) of measures that could be implemented to reduce greenhouse gas emissions and the costs and effectiveness of those measures.

[49] Cost-effectiveness is considered by air quality managers during the single-source permitting reviews for BACT, when more costly technologies may be discarded.

Figure 3. GHG Abatement Cost Curve[50]



However, no similar analysis was conducted for criteria pollutants. Doing so certainly is a non-trivial endeavor, but such an effort is likely to be easier than the GHG cost curve McKinsey already developed and almost certainly could build upon it. Developing criteria pollutant cost curves is an essential step to enabling IMPEAQ and is integral to IMPEAQ's ability to inform air regulators and stakeholders.

With its substantial technical capability, EPA certainly could develop cost curves that could serve as a default for states to use, much like the agency does today for default emission factors with its *AP-42, Compilation of Air Pollutant Emission Factors*.[51] States should be free, however, to develop their own cost curves for criteria pollutants and/or to modify or supplement default ones provided by EPA or others.[52] While better cost curves are always welcome (i.e., more frequently updated, more accurate cost and effectiveness data, greater option segmentation, etc.), cost curves need not be unduly complex, difficult, or expensive for policy planning purposes. Optimization modeling against even simple measures databases can provide valuable policy insights, and gaining familiarity and alacrity with rudimentary data and optimization may

50 McKinsey & Co., 2007.

51 For more information on EPA's AP-42, see http://www.epa.gov/ttnchie1/ap42/.

52 For compliance purposes, state-developed cost curves from which future air quality benefits would be projected would likely require verification and/or validation to ensure that they reflect implementable options and credible cost and effectiveness data.

provide greater insight and benefit faster and cheaper, rather than exhaustive, data gathering and processing efforts.

Once pollutant-by-pollutant cost curves are developed – or at least once measure-specific pollutant reduction results and costs are available – additional work will be necessary to generate the "emission reduction opportunity curves" necessary for an IMPEAQ process. Specifically, beyond the cost and pollutant reduction impacts (which emissions they reduce and by how much) of each control measure, it will be necessary to add further measure-specific information about their impacts on electricity generation and use, practical limits to their uptake or penetration, interactive effects (positive or negative) with other measures, feasibility characterizations, and other information to create a comprehensive database of interrelated options that can be responsive to optimization against energy and emissions criteria. This database is conceptually illustrated in the hypothetical example shown in Table 1.

Table 1. Illustrative Measures Database

ID #	Descrip-tion	Sources	Cost	Units	SO2 Impact	NOx Impact	CO2 Impact	HAPs Impact	Pene-tration Limit	Interactions with Other Measures	Feasi-bility (1-10)	Etc …
1	RPS	EGUs	$50	MWh	Y	Y	Y	Y	x	#2, #3	9	x
2	SCR	EGUs	$5000	Ton	N	Y	Y(-)	N	x	n/a	9	x
3	EE	EGUs	-$5	MWh	Y	Y	Y	Y	x	#1, #2	8	x
4	I/M	Cars	$30	Ton	N	Y	Y	Y	x	n/a	2	x

This database would form the foundation for IMPEAQ analyses. While it is impossible to establish and algebraically solve a system of equations that would address all of society's short- and long-term economic, energy, public health, and environmental goals, it is possible to pursue an approach analogous to linear programming to identify optimal solutions. Specifically, optimization models can be designed to identify the best mix of measures to meet multiple specified goals, and/or system dynamics models can be developed that can interactively illuminate the outcomes created by altering multiple inputs.

None of this undertaking can be regarded as easy, quick, simple, or cheap, and the results will likely vary by region. However, these tools have been applied to equally complex issues and data sets; indeed, they were invented to deal with complex multi-variable problems. And given the magnitude of the expenditures associated with controlling air pollution from major sources, let alone those associated with its harms to public health, comprehensive optimization analyses could produce significant savings.

Happily, the IMPEAQ concept is not an all-or-nothing endeavor. As suggested earlier, IMPEAQ analysis can be piloted with a limited subset of pollutants and/or measures, revised and refined as necessary, and scaled up to include several pollutants and hundreds of measures. Further, each state could tailor the measures database that it uses, so that IMPEAQ results would reflect an optimization applicable to their specific circumstances, economies, and goals.

Note that the purpose of IMPEAQ is to optimize policy measures across multiple sources, pollutants, goals, and timeframes. It is not the purpose of IMPEAQ to substitute for existing air quality impacts modeling, which ascertains the impacts on ambient air quality of emission reductions accomplished by certain control measures. Accordingly, it will be necessary for a state applying the IMPEAQ approach to determine though preliminary air quality modeling the desired level of reductions – in tons of pollutants – necessary to achieve its goal. This process requirement underlies our first key question (i.e., "how clean and by when"). Meeting this requirement, we believe, is best served by an approach that RAP has previously recommended and is currently exploring with EPA called "Top-Down Tons." Under this approach, a state or EPA would conduct air quality modeling to determine what amount of emission reductions of which pollutants are necessary to achieve its air quality goals. The resulting quantity of tons to be removed would be input to the IMPEAQ process, by pollutant, along with other reliability and societal goals, and the IMPEAQ process would determine an optimal path for achieving them all together.

Similarly, IMPEAQ would not substitute for dispatch modeling. It would provide output that, depending on the design and accuracy of the measures database, could include energy demand reductions and conceivably some timing information (e.g., typical seasonal character of the emission reductions, if any; typical time of day impacts; etc.). Dispatch modeling, where of interest to states and/or sources, would typically follow the IMPEAQ process.

5. How Does IMPEAQ Address the Identified Barriers; Why is it "Better"?

Section 3 described several barriers that have obstructed serious progress towards multi-pollutant air quality plans. This section describes how IMPEAQ would

Institutional

Barrier: Resources – State air regulators are concerned that taking time away from mandatory SIP development will have serious impacts on their ability to get approvable SIPs completed on time. In addition, state budgets are in poor shape, with little discretionary funding available. These obviously are valid concerns.

How IMPEAQ addresses barriers: President Obama's September 2011 decision not to accept EPA's ozone NAAQS recommendation, and recent delays in the process to consider revisions to the $PM_{2.5}$ NAAQS, may have given states some extra breathing room. While there are many other and often competing priorities, the next two years appear to be an excellent time for one or more states to pioneer the implementation of an IMPEAQ process. IMPEAQ would enable states to “get ahead” of obligations that could be imposed as a result of NAAQS revisions. Otherwise states will always remain in a responsive rather than a proactive position with respect to changing air quality obligations.

States also may wish to transition step-wise toward the multi-pollutant, least-cost planning process. An example of a possible transition process could be:

- First, undertake planning for just two pollutants, e.g., ozone and fine particles. The NAAQS for both of these pollutants are expected to be revised in the 2013-2014 timeframe.
- Second, transition from a two-pollutant plan to the IMPEAQ multi-pollutant plan that we emphasize here. The four major Clean Air Act programs undergo periodic revisions, with NAAQS, NSPS and MACT standards being promulgated or revised on predictable schedules.
- Third, states can request a “bump-up” to a higher classification to provide them with more time to develop and implement control measures. This option is already being considered by some states classified as marginal under the 2008 eight-hour ozone NAAQS, because these states believe three years is insufficient time to reduce pollutant emissions.

While the period between now and the end of 2013 is an ideal time for states to consider an IMPEAQ,[53] the comprehensive, least-cost environmental planning framework embodied in IMPEAQ would help a state to meet Clean Air Act objectives whenever they occur.

Structural

Barrier: Inertia – “We’ve always done it this way” and have been successful.

How IMPEAQ addresses the barrier: Using the power sector as an illustrative example, states and EPA have reduced NO_X and SO_2 emissions significantly through the Acid Rain Program, NO_X budget program, and the first phase of the Clean Air Interstate Rule (CAIR). Some states have adopted requirements to reduce mercury emissions, and EPA’s mercury and air toxics standards (MATS) rule anticipates achieving further significant reductions by 2015 or 2016. EPA has proposed or adopted several new air, water, and land management regulations for the power sector. Regardless of the merits of the contentious exchanges surrounding EPA’s recent suite of

[53] EPA’s Ozone Advance program also encourages early actions by states to reduce ozone pre-cursors prior to the next revision of the ozone NAAQS. The Ozone Advance guidance focuses on one criteria pollutant. An equivalent argument could be made for “Fine Particle Advance,” because EPA is scheduled to publish a revised $PM_{2.5}$ NAAQS at the end of 2012 or early 2013, and early actions by states could also reduce fine particle, sulfate and nitrate emissions.

air regulations, the core arguments could reasonably be summarized as, “We cannot continue to regulate air quality this way.”

One reason is cost. The United States spends over $1 trillion annually on energy consumption. Of that sum, $350 billion is spent annually by customers to purchase electricity. Likewise, the United States spends about $2.5 trillion on health care costs. Both energy costs and public health care costs continue to rise.

Two recent studies highlight the costs associated with existing power plants, one on the costs to meet recent air quality regulations, the second on the public health costs imposed from existing fossil-fuel fired generators. The Bipartisan Policy Center (BPC) completed an analysis that estimated the costs to meet new air quality regulations. BPC’s analysis reflected estimated costs of $469-596 per kilowatt (kW) for wet flue-gas desulfurization (FGD) to remove SO_2, $350-450 per kW for selective catalytic reduction (SCR) to remove NO_X and $142-168 per kW for fabric filters to remove mercury.[54] Taken together, the BPC estimates range from $961 to 1,124 per kW.

Second, the National Academy of Sciences (NAS) published a report, “Hidden Costs of Energy,”[55] which concluded that the average health cost imposed by fossil fuel power plants is $34 MWh. In certain parts of the United States, the NAS study indicated, these costs are as high as $120 per MWh.

A IMPEAQ process would reflect upon the NAS and BPC work and address such questions as:

(1) What resources does my state need. and what is the most cost-effective way to provide them? and

(2) How do new energy efficiency, distributed generation, and renewable resources compare with new gas, nuclear and coal-fired generation?

These are different questions than are typically asked today. Had those questions been asked in 1990, the billions of dollars spent to reduce SO_2 and NO_X might have reduced mercury, GHGs and improved water quality as well, and perhaps also lowered ratepayers’ electric and gas bills.

What are the implications of asking questions like these today? Supply side resources like CHP are highly cost-effective, help a business to stabilize its energy costs, and reduce the future risk and uncertainty associated with fuel and electricity price volatility. Clean demand response (i.e., load management measures that do not use back-up diesel generators) reduces peak electricity prices and can avoid the use of uncontrolled generators during peak demand periods. Renewable resources like solar may today be priced higher on a levelized cost-basis, but such

[54] Macedonia, J and Kelly, C; Bi-Partisan Policy Center, “Projected Impacts of Changing Conditions for the Power Sector”, July 2012. http://bipartisanpolicy.org/sites/default/files/Electric%20Power%20Sector.pdf

[55] National Research Council of the National Academy of Sciences, “Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use”, October 2009.

resources also have generation profiles that coincide with peak load periods and can help assure reliability. Storage technologies, like domestic hot water heaters, can be married with renewable resources like wind and solar to act as distributed "batteries" that dampen the variability that can occur with these renewable resources.

The idea in IMPEAQ is to forthrightly address issues like these questions and topics and to project possible answers forward in order to more prudently consider important, foreseeable events and issues.

Today, many states evaluate new energy efficiency by comparing the costs of efficiency to that of existing coal or gas generation. This view compares the costs associated with amortized plants (thus, generally favoring operating costs) with the expensed costs of new energy efficiency investments, in other words, comparing old vs. new and capitalized vs. expensed costs. A more prudent comparison would compare new with new. What are the costs avoided by new energy efficiency resources? Comparing the costs of new resources is straightforward. A Lazard analysis reflects costs of $0-50 per MWh for energy efficiency, $74-135 for coal, $73-100 for natural gas combined cycle and $98-126 for nuclear.[56] Energy efficiency and renewable energy are also not susceptible to variations in fuel prices or regulations to reduce GHG emissions, so they provide a prudent hedge against market volatility and are important resources to help meet state climate change goals. In addition, these resources can simultaneously address multiple pollutants, provide economic and job creation benefits, mitigate other risks, improve technological competitiveness, and enhance national and energy security.

Analysis of the true costs and benefits, including externalities, needs to be transparent and robust. The energy sector today believes that it has shouldered proportionately more of the burden to reduce air pollutants than other sectors. These concerns make it incumbent on air quality and energy regulators to coordinate planning even more so in the future. Further, programs like electrification of ports and marine terminals, and future penetration of electric vehicles in the transport sector, may lead to reductions in hydrocarbon, fine particle and SO_2 emissions. This shift could increase the share of emissions emanating from the electric power sector and, correspondingly, the likelihood that future air quality programs will seek additional emission reductions from this sector.

IMPEAQ would also address non-criteria pollutants. Forty-plus years of air quality planning have substantially reduced criteria and many toxic pollutants. However, GHG emissions have continued to rise – by 14% since 1990[57] – even as criteria pollutant emissions continue to

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56 Lazard, Levelized Cost of Energy Analysis, Version 2.0, June 2008. and CERES, *Ibid* (see figure 10 on page 28) .

57 EPA fact sheet on GHG emissions, undated. Accessed via http://epa.gov/climatechange/indicators/pdfs/CI-greenhouse-gases.pdf

decline. Also, a focus on reducing short-term peak concentrations of pollutants may address acute health effects, but, globally, annual average concentrations of ozone continue to increase at a rate of 1-2 parts per billion per decade[58]. Mercury deposition is also dispersed globally.

Barrier: Energy efficiency does not work – How do we know that energy consumption is lowered after energy efficiency measures, programs, and projects are completed? How do we know that the energy savings will persist over time?

How IMPEAQ addresses barrier: The evaluation, measurement, and verification (EM&V) of energy efficiency programs follows established protocols that are used by most U.S. programs. State PSCs review and approve EM&V programs. PSCs also issue orders for how energy efficiency programs are to be implemented and how energy savings are to be audited, recorded, and reported. Some states[59] contractually obligate the energy efficiency program administrator to achieve a required level of energy savings. These procedures and protocols are equivalent to those used to measure air pollution reductions using end of pipe controls and may be more precise than the procedures that are used to determine mobile source emissions SIP credits.[60]

Overcoming this barrier requires education and knowledge about how state PSC's operate and how they review and approve energy efficiency programs. A recent exercise involving the State of Connecticut, EPA Region 1, EPA's Office of Air Quality Planning and Standards, and Connecticut's energy efficiency program reviewed that state's energy efficiency technical support document (an annual report of energy efficiency and audited results that is submitted, reviewed and approved by the state's PSC). EPA was persuaded that Connecticut's EM&V was of sufficient quality that it could include energy efficiency as a creditable measure in its ozone SIP.

An example of where energy efficiency might be applied as a control measure to meet future air quality standards comes from the Pacific Northwest. A summary of energy efficiency programs completed since 1980 demonstrates that energy efficiency works, shows the persistence of energy savings over time, and their cumulative energy benefits. Based on results of long-term EM&V by the Northwest Power and Conservation Council (NPCC), since 1980 energy efficiency measures have met over 50% of that region's load growth, produced cumulative savings of 5,000 MWa (enough to nearly serve the electricity load of Oregon), saved consumers over $3 billion, and now represent that region's third-largest resource, after hydropower and coal.[61]

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[58] U.S. EPA, GEOS-Chem simulations of the influence of sources inside and outside North America on U.S. ozone (Zhang, et al., 2011)

[59] Notably Vermont.

[60] States with vehicle inspection and maintenance programs received emissions credit based on EPA modeling.

[61] Tom Eckman, NPCC, "Progress Towards the 6th Plan's Regional Conservation Goals", September 12, 2012. Presented to Northwest Power and Conservation Council. NPCC covers the four state region of Washington, Oregon,

As with evaluation and measurement of air pollution control measures,[62] the evaluation, measurement, and verification of energy efficiency practices also has evolved and improved over time. Practices specified by a PSC evolve similarly as experience and learning occurs. This fluid, continuous process can accommodate the perspectives and needs of the air agencies if they are expressed in a way that promotes convergence of the priorities of both utility and environmental regulation. In other words, over the long run, air directors do not simply have to accept the EM&V system they find but can influence the practice of EM&V to address air quality, as well as energy savings and economic objectives.

Barrier: Energy consumption will increase after energy savings measures are installed – This argument posits that, once people see that their new energy bills will lower monthly costs, they will leave the lights or TV (or other energy consuming devices) on more. This is known as the "rebound effect."

How IMPEAQ addresses barrier: It is common practice to develop net energy savings estimates to attribute the effects of specific efficiency investments and common to account for rebound effects, among other outcomes, in doing so. Rebound means that individuals have a little extra money to improve their quality of life and that what they choose to do with it will sometimes involve using more energy elsewhere in their lives.[63]

"Spillover" is another important result of energy efficiency programs. Spillover refers to additional energy-efficient equipment installed by a customer due to program influences but without any financial or technical assistance from the program.[64] Spillover gets far less attention than rebound, and there is evidence demonstrating that spillover effects exceed rebound effects. A joint study of energy efficiency program savings commissioned for four Connecticut and Massachusetts utilities found that spillover ranged from 3% to 34%, depending on the program and customer class.[65] Several studies completed for and discussed at Northeast Energy Efficiency Partnership's (NEEP) Evaluation, Measurement, and Verification (EM&V) Forums show similarly positive spillover benefits.[66]

Idaho and Montana. Based on actual 2010 dispatch/contribution, hydropower contributed 46%, coal 18% and energy efficiency 16% of that region's energy resources.

[62] For example, air quality agencies have moved from stack testing once per year to continuous emissions monitors and even hand held devices to measure instantaneous emissions.

[63] [Cite to several studies and PSC orders to explain that rebound and its implications are well understood and already sufficiently accounted for in standard practice.]

[64] PA Consulting Group, "2007 Commercial and Industrial Programs, Free-ridership and Spillover Study", Draft Executive Summary, June 10, 2008, completed for United Illuminating Company.

[65] *Ibid,* Sections 1-4.

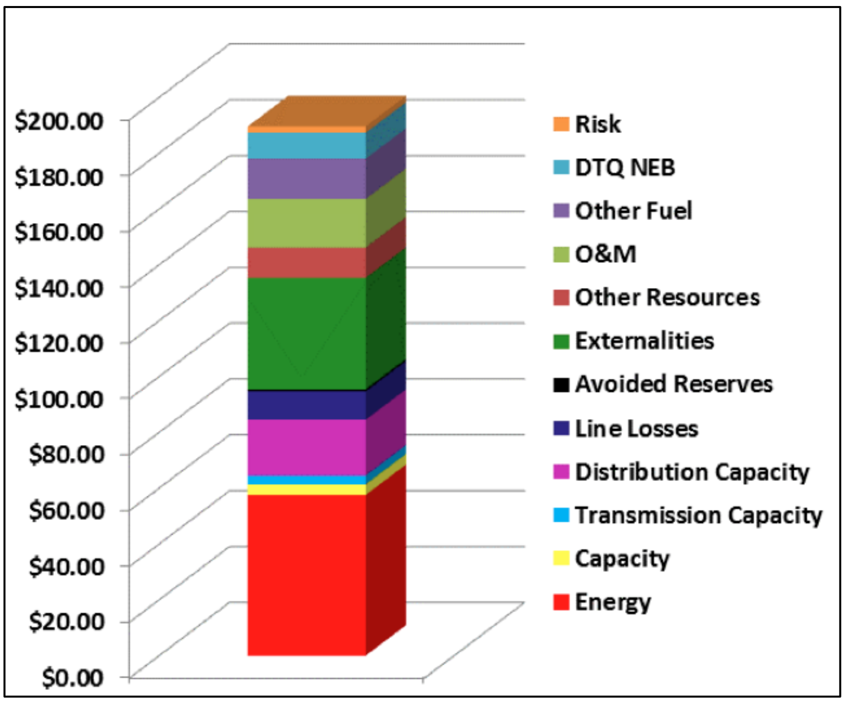
[66] See generally, http://neep.org/emv-forum/emv-library/research-evaluation-studies (links to state studies), and presentations made at NEEP EM&V Forums.

Technical

Barrier: Modeling – What are the benefits from energy efficiency? Where do they occur? To whom should go the credit?

How IMPEAQ addresses barrier: The second and third questions are trickier to address than the first. In the former, thanks to efforts by EPRI to develop a new energy-environment model and the ERTAC group of Northeastern and Great Lakes states and others, there is increased recognition that existing models do not adequately characterize the dispersed and cumulative benefits of energy efficiency. See Figure 4, for example, though even this list does not include water or health benefits associated with reduced generation. Many of these efforts endeavor to develop technical tools that will be available to their members (in the case of EPRI) and to states to help determine the impacts of energy system changes.

Figure 4. Partial List of the Benefits of Energy Efficiency[67]



Where the energy savings occur is a two-part question. First, based on the above EPRI or ERTAC models, or existing electricity dispatch models such as ProSym and IPM, solving for the lowest economic costs to meet reliability standards will be reflected through changes in what units are

67 Lazar and Lamont, RAP, 2012, Vermont Energy Efficiency Savings Value Updated Externality and Non-Energy Benefits ("DTQ NEB" is Difficult to Quantify Non-Energy Benefits; O&M is Operations and Maintenance; "Other Resources" includes water, sewer, and waste).

dispatched in any given hour and their location. The second part of the question is that energy efficiency or renewable energy program investments by one state may result in displacing generation operating in a different state. This result segues into the third question: does it matter, and to whom should the air quality and other credit be given?

If, for example, one state's investment in energy efficiency and renewable energy results in generators being backed down in another state, and this is a beneficial result in a relevant air quality management plan or IMPEAQ, does the state making the EE/RE investment get the credit? One potential solution to this question, which has precedent under the Clean Air Act, is the idea of a "supplemental compliance pool" of allowances. In its simplest form, EPA would withhold a certain percentage of emissions allowances (we would suggest 10% to start with) for qualifying energy efficiency and renewable energy programs. Based on review of a state's program evaluation, measurement, and verification (EM&V) and modeling results (which EPA routinely does for any regulatory program), EPA would assign an appropriate number of allowances from the supplemental compliance pool to the state making the EE/RE investment in consideration of its actions that led to emission reductions in other states within its wholesale electric market area.[68]

Additional Benefits of IMPEAQ

IMPEAQ is a process that enables long-term and comprehensive environmental planning, and its inclusion of energy efficiency and renewable energy will reveal many additional benefits. For example, although our immediate focus has been on air quality benefits, energy consumption and power generation in the U.S. use enormous quantities of water – and vice versa.[69] In California, for instance, about 20% of the state's energy consumption is related to moving water around via pipelines and for irrigation.[70] Reduced and more efficient energy consumption can thus improve water availability and quality as well.

Energy efficiency and renewable energy also produce more jobs per MW than fossil-fuel fired generators.[71] Actual construction of new power plants also produces many jobs, but only for the limited duration of the construction itself. Modern power plants require few people to operate

[68] Other approaches also exist including some that may be more effective in areas without organized wholesale electricity markets. These will be considered in the course of further validation and verification efforts associated with IMPEAQ's development.

[69] See, for example: *Consumptive Water Use for U.S. Power Production*, Torcellini et al, NREL, December 2003; *A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies*, Macknick et al, NREL, March 2011; *How Saving Energy Means Conserving Water in U.S. West*; Glick, Scientific American, August 1, 2011; *No Water, No Energy. No Energy, No Water*, Sarni and Stanislaw, Deloitte, May 2012.

[70] "*How Saving Energy Means Conserving Water in the U.S. West*", Scientific American, August 1, 2011. Accessed via http://www.scientificamerican.com/article.cfm?id=how-saving-energy-means-conserving-water.

[71] *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?*, Kammen et al, UC Berkeley, August 13, 2004 and in Energy Policy 38 (2010).

and maintain them, whereas installation of energy efficient measures, appliances, and small-scale renewables require a trained and local labor force to install and maintain such devices.

6. Process: Description of the IMPEAQ Process

Although the up-front effort necessary to conduct an IMPEAQ analysis would be significant (as it is for utility IRPs), IMPEAQ's outcome would make the SIP process administratively easier and less expensive. This is in part because IMPEAQ would help states develop measures that could satisfy many SIPs over a long period. Full implementation of the IMPEAQ approach will require the development of a comprehensive optimization model and/or system dynamics model, as well as the construction of a comprehensive database of measures, programs, technologies, and other options that can reduce emissions. The database would include traditional end of pipe solutions, efficiency and renewable energy options, and many other polices, programs, or technologies.

The IMPEAQ process is envisioned to comprise the following steps, illustrated in Figure 5.[72] Steps 1-3 of the process would primarily involve air quality planning and modeling staff, though collaboration with PSC staff would be important in constructing and running the measures database and model referenced in Step 3. Step 4 would require early engagement of public service commission staff to compare assumptions on energy-related variables, such as load growth, energy savings from energy efficiency programs, and renewable energy development. It may also be wise to involve staff from the regional transmission organization (if one exists for the particular region) or the entity responsible for operating the region's electricity grid. Step 6 will primarily involve air agency staff but could involve PSC orders or decisions as well.

1. Review air quality monitoring data for the state or area(s) of concern to determine the design values for criteria pollutants. Use the most recent version of the state's emissions inventory and the most recent monitoring data available.
2. Compare the existing design value[73] for each pollutant with that needed to reach attainment with the current NAAQS and the anticipated future NAAQS. Applying the "top-down tons" approach, calculate through air quality modeling the number of tons of each pollutant that must be removed from the air shed in order to reach current and

[72] [NOTE: This is an initial process sketch; revisions are likely to be needed as optimization modeling and/or systems dynamics modeling applicable to IMPEAQ comes into better focus. Many of these steps will be incorporated as inputs to or outputs of optimization or system dynamics modeling.]

[73] States and EPA analyze air quality monitoring data to determine which monitor in a given airshed records the highest pollution levels. EPA regulations specify data quality assurance and control procedures. A state is allowed one NAAQS violation per year, and for planning purposes, data are averaged over a three-year period. The design value for ozone represents the 4th highest concentration of that pollutant at a given monitor. States are also permitted one NAAQS violation per year for $PM_{2.5}$, along with exceptions for events like wildfires and 4th of July fireworks. The design value calculation for $PM_{2.5}$ is more complicated, and determined arithmetically per EPA guidance.

expected future NAAQS. Establish similar targets for reductions in state emissions of HAPs and GHGs.

3. With the number of "top-down tons" established for each pollutant, states are in a position to run IMPEAQ optimization modeling or system dynamics modeling, incorporating various assumptions about the future. This process should be conducted in close collaboration between environmental and energy regulators.[74] The IMPEAQ modeling would identify optimal groupings of database measures that would comprehensively achieve the required tonnage reductions for each pollutant, at least cost, with minimum reliability and other electric system impacts, and greatest co-benefits. The execution of this step is not possible, however, until:

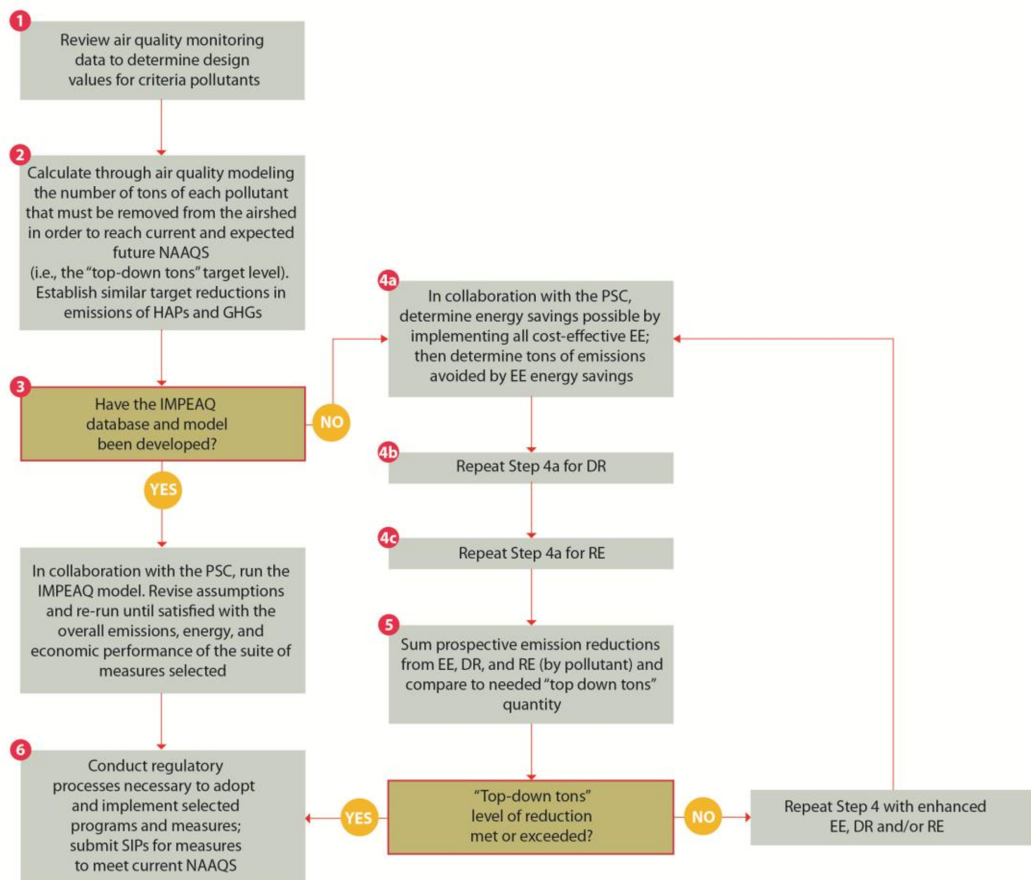
    a. The IMPEAQ database described in Section 4 is created. This database forms the foundation for comprehensive, multi-pollutant IMPEAQ analyses. Essentially, it identifies the components of cost curves (i.e., measures) for all pollutants of concern, along with their costs, co-benefits, electric system impacts, etc. States , regional organizations (e.g., NESCAUM, LADCO, SESARM, WESTAR, etc.), or EPA could create generalized databases to serve as a starting point for individual state efforts; individual states could then tailor the database to their specific circumstances.

    b. The IMPEAQ optimization or system dynamics model(s) – also described in Section 4 – are developed. Using the pollutant cost curves and other data incorporated into the IMPEAQ database, this model will determine optimal outcomes that meet specified constraints, particularly the need to achieve the required "top-down tons" emission reductions for each pollutant of concern.

   If the IMPEAQ measures database and optimization or system dynamics model have been created and are in operation, states can run them and skip directly to Step 6. If they are not yet available, states can still benefit from the IMPEAQ approach by executing Steps 4-5 below.

[74] A regional transmission operator (RTO) might also include assumptions regarding future air quality standards and requirements in the long-range transmission planning efforts that the RTO completes.

Figure 5. Schematic Illustration of the IMPEAQ Process



4. Convene discussions with the public service commission to consider how existing or future energy efficiency and renewable energy programs in the state could help achieve current and future air quality standards and requirements.[75]

    a. Make the case that cost-effective energy efficiency is universally or nearly universally a cheaper air quality strategy than any pollution control device. Then determine the quantity of energy savings that could be achieved in the state from implementing all cost-effective EE (and over what timeframe). Determine the emissions avoided or displaced by these energy savings, the costs of the

[75] [Reviewers' advice is welcome as to whether this paper should also: (a) provide advice for how to accomplish this convening, particularly in states with little track record of innovation and/or where agencies may not have interacted historically;.(b) create a model statute or executive order that would enable such collaboration in states where additional authority or impetus may be required; and/or (c) a model regulatory order from the agencies regarding interagency collaboration.]

programs, any co-benefits they may have, etc. Determine the number of tons of air pollution avoided or removed using one of the techniques described below. Based on that calculation, determine how many tons of reductions are still needed to meet goals.

i. Marginal emissions analysis: This assumes that energy efficiency and renewable energy displace the last unit that runs in any given hour or day. These data are available from regional transmission organizations (RTO), or absent such organizations, from the utilities. Note that the marginal emissions unit can be natural gas or coal, or less often from another resource type.[76]

ii. Stochastic modeling: This analysis takes a snapshot of actual generation that occurs in a state for a one-year period. It assumes that the future will behave like the frozen one-year and introduces substitutions of energy efficiency and renewable energy generation per the state policies being analyzed.

iii. Electricity dispatch modeling: This is a comprehensive analysis of how resources are dispatched over time. Energy efficiency and renewable energy resources are introduced, and the model results reflect what generating units are affected and their location by hour, day, and month.

iv. For purposes of air quality planning, any of the above three techniques is satisfactory. The regulator's goal at this stage is to assess potential energy savings and the associated emission reductions. However, utilities and RTOs routinely conduct dispatch modeling for IRP and other planning purposes. Participation by air regulators in these existing processes could prove a cost effective way to determine energy savings and emission reductions and could also help to inform and improve them (e.g., by providing input on the assumptions and variables that the RTO or utility models).

b. Complete a similar process for demand response (DR) programs and initiatives.[77]

c. Complete a similar process for renewable energy (RE) programs and initiatives.

[76] See ISO-NE, Environmental Advisory Group, Meeting Materials, December 4, 2009; and ISO-NE, Environmental Advisory Group, Meeting Materials, April 20, 2012.

[77] Note: RAP is currently leading an effort to develop a cost effectiveness framework for DR programs.

5. On a pollutant-by-pollutant basis, sum the quantity of tons saved or avoided from the energy efficiency, demand response, and renewable energy policies. Compare these sums to the total quantity of tons that needs to be removed from the air shed in order for the area to attain the current and future NAAQS. If additional pollution reductions are still needed, the state should consider redoing the above analysis (Step 4) with enhanced EE, DR, and RE programs, particularly if the initial analysis did not consider all cost-effective EE, sufficiently aggressive DR, and/or assumed little RE development. In doing so, the state should compare these options and their costs to pollution control devices and their costs (limiting this calculation to just power sector control devices). The state may also wish to consider implementing control measures applicable to other sectors in order to get additional tons out of the air.[78]
6. Conduct additional regulatory processes (by the PSC or environmental agency as appropriate) as may be necessary to adopt the selected measures, and once implemented, submit to EPA as SIP revisions such measures as may be necessary to meet current NAAQS.

Note that in states that are investing, or plan to invest, in infrastructure to electrify the transportation sector, air regulators will also want to convene discussions with their department of transportation (DOT) and PSC colleagues together, to review DOT's planning assumptions and the potential influence that electric vehicles may have on generation. This sort of excursion in the process may also be needed to deal with transmission issues necessary to integrate large-scale renewable energy into the grid.

Earlier we recommended exploring an initial IMPEAQ multi-pollutant, least-cost analysis with only a limited set of pollutants (e.g., $PM_{2.5}$ and ozone). The above steps illustrate the same caution with respect to control options, limiting them to primarily energy efficiency, renewable energy, and demand response options. This is appropriate until the larger options database(s) and optimization models are developed and tested. Within these understandable current constraints, we hope that the above steps provide insight into the opportunity for better, more cost effective, long-term air quality management that we believe the IMPEAQ approach can provide.

7. Conclusions and Recommendations

IMPEAQ is a process tailored to meet the particular air quality needs of a state. An IMPEAQ process for Maryland will not be the same as IMPEAQ processes for Illinois or Washington. A Maryland IMPEAQ may emphasize regionally consistent measures to reduce local and

[78] While this initial discussion of IMPEAQ is limited to consideration of the power sector, a full-blown implementation of IMPEAQ could certainly include measures and cost curves applicable to other sectors and could conduct optimization modeling across sectors.

transported pollution. An Illinois IMPEAQ could emphasize toxic pollutant benefits in urban areas and reduced transport of smog across Lake Michigan. Washington is concerned about acid deposition into Puget Sound, so water quality benefits may receive equal consideration to improved air quality in its IMPEAQ.

More than 40 years of progress in cleaning the air in the United States highlights the strength of the Clean Air Act and the states that implement its provisions. However, the entire basis for which the original Act was enacted, and even the 1990 Amendments, has evolved significantly, as has the nature of the challenges we face. The power sector is restructured in many states; regional transmission organizations operate much of the nation's electricity grid and are responsible for maintaining its reliability. We know a lot more now than we did in 1965 or 1990. We have a better understanding of how pollutants react with each other in the atmosphere, and we understand their individual effects on human health and the environment in greater detail. We are learning more about the cumulative and interactive effects of various pollutants and how water quality and land impacts are not limited to acid deposition. But, each time we learn more about a particular pollutant or strengthen a standard, we have incrementally added requirements. This approach has achieved significant results but appears to be nearing its limits economically and politically. Further, the stove-piping it has engendered may have actually hindered our ability to conceive and execute integrated solutions to address multiple pollutants and issues simultaneously.

Qualified air pollution professional entities like the Clean Air Act Advisory Board and the National Association of Clean Air Agencies have recommended that states and EPA develop multi-pollutant plans within the existing framework of the Clean Air Act. The structure and framework of the Act are sufficiently comprehensive and flexible to accommodate, if not explicitly to encourage, a IMPEAQ approach. Today's difficulties with clean air standards are a reflection of their complexity and the continual uncertainty the public and the regulated community experience about existing regulations and new forthcoming standards. Visceral reactions to new regulations are partly ideological and partly a fear of economic harm; but, if one fully analyzes the messages intended for public consumption of groups that oppose new regulation, the negative reactions at their core relate to a sense that the Clean Air Act may have been successful in the past but has increasingly become a regulatory burden, that few understand it, and that its implementation is inflexible, unpredictable, and inconsistent.

IMPEAQ is an attempt to emphasize the fundamentals embedded in the Clean Air Act. This paper represents RAP's thinking regarding a simpler, but we believe more effective and protective, process to improve air quality management. IMPEAQ reflects real air sheds, real markets, and real solutions. EPA and states have considerable flexibility over what control measures are selected, their efficacy, and the processes to approve and implement regulations. Mobile source and area source emission programs for decades have had less rigorous means to certify their effectiveness than stationary source programs. The latter are easier and bigger targets to regulate, and their emissions can be readily verified through instrumentation. But, EPA and the states have often looked at energy efficiency and renewable energy through the same lens as installing end of pipe controls on a power plant, rather than looking at them analogously to mobile or area sources, as actually befits them. This view has impeded consideration of EE and RE and increased transaction costs to assess their environmental benefits.

We believe the need and timing to design and demonstrate an IMPEAQ analysis are favorable and that there are both forward-looking and defensive reasons to do so. This paper has described many of the forward-looking reasons. Current events suggest that there are equally good defensive reasons for an IMPEAQ today and that not moving toward an IMPEAQ approach will increase the likelihood that the Clean Air Act will be regarded as a burden, to the detriment of air quality planning, public health, and economic competitiveness in America.