EXTERNALITY ADDERS AND COST-EFFECTIVE EMISSIONS REDUCTIONS: USING TRADEOFF ANALYSIS TO PROMOTE ENVIRONMENTAL IMPROVEMENT AND RISK MITIGATION

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ABSTRACT

In an effort to require electric utilities to assess the environmental impacts of their activities, public utilities commissions nationwide have been turning to the use of environmental externality valuation as a tool in integrated resource planning. To date, policy discussions have focused predominantly upon the correct value and calculation of externality adders, rather than their use and applicability as a planning tool. By focusing discussions upon the unknown, and essentially unknowable, health and environmental damage costs of residual emissions, the distinctions between socially equitable electric service, environmental risk mitigation, and cost-effective emissions reductions have been blurred. This paper discusses the use and utility of externality valuation for identifying low-cost, low-emissions electric service strategies. Using data obtained from a broad based examination of New England's electric service options, this paper compares the externality valuation concepts being employed by several state regulatory agencies with the information generally obtained from electric power system simulation and production-costing analyses. While a valid economic concept, the application of externality values is of little use in identifying which strategies are both low-cost and low-emissions, or the specific policy options required to ensure their implementation. Externality valuation should therefore only be used as a last step, to select from among low-cost, low-emissions strategies once the aggregate cost and emissions impacts of those strategies have been identified.

INTRODUCTION

In recent years, public utilities commissions have been exploring (and adopting) ways for electric utilities to incorporate environmental considerations into their resource planning and acquisition activities. There are many proposed methods, often based upon the microeconomic concepts of external costs and externalities, employing analytic tools such as ranking and weighting of resources and the monetization of residual emissions. [1, 2] One of the most prominent (and controversial) techniques adopted relies upon the use of monetized externality adders in Integrated Resource Planning (IRP). While the regulatory motivation and microeconomic foundation for including external costs in utility resource planning is sound, reliance on the monetized adder approach signifies a shift away from the least-cost planning techniques the industry has strived to develop over the past decade, towards methods which look only at competing new resources, instead of the entire infrastructure, and seek to capture consumer value, without an understanding of the cost and emissions impacts of those decisions.

This paper will briefly review the regulatory motivations for incorporating environmental considerations into utility resource planning, explore the mismatch between the monetized adder approach and traditional integrated resource planning objectives, and finally show how rigorous application of existing IRP tools is more successful at achieving cost-effective emissions reductions given the vast uncertainty regarding the economic benefits of further reducing emissions.

MOTIVATION VS. APPLICATION

Motivation. The regulatory motivation to include the environmental impacts of "residual" emissions (i.e. those emissions remaining after compliance with environmental regulation) in resource planning is well founded. The chairman of the Vermont Public Service Board communicated the regulatory perspective during a recent national conference on integrated resource planning. He stated that state utility regulators had three fundamental reasons for wanting to include more environmental factors in resource planning. First, regulators have a *moral obligation* to see environmental considerations included in the resource selection process. While the magnitude of the health and environmental impacts resulting from residual pollutant emissions may not be known, this does not mean they are zero. Since these environmental costs exist, it is the responsibility of civil servants to see that they are considered–in some manner–in utility planning. Second, it is *economically sensible* that these factors be included. Given the trend towards broader and stricter environmental regulation (think CO_2), and that it is likely that resources selected now will be subject to changes in environmental regulations over their lifetime, consideration of whether a given resource strategy will put electric customers at environmental or regulatory risk is also reasonable. Finally, state regulators have a *strategic opportunity* to promote broader change by requiring the inclusion of environmental criteria in regulated utility decisionmaking. Federal automotive and appliance efficiency standards are an example of regulations that were enacted based upon the experiences gained via the actions of individual state agencies and legislatures. [3] As the chairman concluded, "Our strategic advantage is our ability to act."

Application. Recognition of these opportunities and responsibilities has hastened the application of "social costing tools" in integrated resource planning, transforming and expanding traditional least-(direct)-cost planning to least-social-cost planning. The Massachusetts Department of Public Utilities (Mass. DPU) has clearly expressed their intention in this regard during their overhaul of electric utilities' resource solicitation processes. As stated, the goal of the Mass. DPU's Integrated Resource Management

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process (IRM) is to institute a framework for resource acquisitions which will deliver "reliable electric service to ratepayers at the lowest total cost to society." [4]
Regulatory consideration of environmental impacts in integrated resource planning have focused predominantly on completing the social cost equation, that is, adding to the traditional internal (or direct) costs of electric service the external costs associated with the health and environmental damages associated with those services. Although neat and clean in terms of microeconomic theory, the task of identifying the damages, which emissions they resulted from, and quantifying the external cost or "environmental externality" is quite difficult. It is in fact the inability to ascertain these external health and environmental damage costs that leads to much of the controversy in the externality debate.

In lieu of actual damage costs, theorists have strived to develop proxy measures for these costs, in particular, ones that are amenable for inclusion in integrated planning and competitive bidding processes. It has been from the development of these proxy measures that much of the controversy has arisen. And it has been the selection of proxies based upon "implicit valuation" rather than "damage valuation" that heralds the implicit shift in utility regulation.† The Mass. DPU recently reaffirmed its use of monetized externality adders in this regard. Through an adjudicatory process the Mass. DPU decided whether to remain with the "implied valuation" (IV) approach or to shift to the "damage valuation" approach. Although recognizing that the damage valuation method, which seeks to directly quantify the health and environmental damage costs associated with residual pollutant emissions, was the preferable approach, the department chose to remain with the IV method. In their judgment the calculation of damage costs via direct estimation (loss of productivity), and/or societal risk mitigation (contingent valuation and offset markets for emissions reductions) did not meet their criteria for comprehensiveness and reliability.

The Mass. DPU's selection of the implicit valuation approach signifies a radical shift away from the utility regulator's tradition of rate base, or revenue based regulation. In the decision they define the IV method as follows:

> "The IV method infers the value placed by society on emissions by using the cost required by society to avoid these emissions. The value placed by society on emissions control is estimated as the dollars per ton derived from the cost of installing the marginal pollution-control technology utilized for compliance with environmental regulations" and "Since environmental regulations are established through a political decision-making process involving input from the scientific community, members of the public, environmental organizations, and competing economic interests, the IV method represents a reasonable proxy for what society as a whole is willing-to-pay to avoid damages from pollutant emissions." [5]

† In the Mass. DPU's discussions the term "valuation" can refer to either "quantifying costs" or "establishing worth."

By benchmarking the external cost proxy measure (the externality adder) to society's alleged willingness-to-pay, utility regulation begins to assess society's value for services by attempting to maximize consumer welfare, rather than minimize consumer costs. There are additional shortcomings to the method. In addition to the ones mentioned below is the recognition that environmental regulators' "willingness-to-charge" (on a unit basis) for a required reduction is larger than their likely "willingness-to-pay" to reduce emissions below levels they have not seen prudent to require.

VALUE MAXIMIZATION VS. COST MINIMIZATION

<u>Cost Minimization and Utility Regulation</u>. Introductory economics texts commonly use the term "willingness-to-pay" when defining consumers' or society's demand for a particular good or service. Fundamental to microeconomics is the distinction between suppliers' marginal costs and consumers' marginal value for a commodity. However, when it comes to state-sanctioned monopolies, regulators have focused almost exclusively upon cost based regulation, including minimization of revenue requirements, average cost pricing, and allowing earnings only upon capital investments. Except for the development of demand charges and time-of-use rates, consumer's willingness-to-pay and price elasticity of demand has played little or no role in utility resource choice and rate based regulation. Figure 1 shows the inherent difference between pricing in the competitive market and revenue based regulation for an electric utility.

As the figure illustrates, the collective customers' willingness-to-pay (for electric service) defines the marginal demand curve. The area under the curve defines society's value for the service. The marginal cost curve is effectively the industry's supply curve for providing a given quantity of service. In a perfect competitive market price equals marginal cost (P_{MC}), and the quantity of service delivered adjusts with the consumers' value and suppliers' costs (Q_{CM}). The competitive industry's revenues are represented by the area 0-Q_{CM}-E-P_{MC}, with industry earnings being the area between industry's marginal cost curve and P_{MC} (less taxes). The *only* significance of the consumers' marginal demand is in describing where marginal demand equals marginal cost.

To avoid the use of monopoly power utility regulators have traditionally employed revenue based regulation, seeking to minimize industry revenues to the level that meets the utilities' "obligation to serve" at least-cost, with earnings tied to capital investments rather than total revenues. In Figure 1, the revenue requirement is described by the area below the marginal cost curve between 0 and Q_{RU}. Note that consumer's willingness-to-pay, and therefore consumer value maximization plays less of a role here than in the competitive market example.

<u>Society's Willingness-to-Pay vs. Regulators' Willingness-to-Charge</u>. Is the distinction between consumer value and consumer cost important? Yes. Under revenue based regulation the consumer surplus, that area between the marginal demand curve and the customers' cost for the

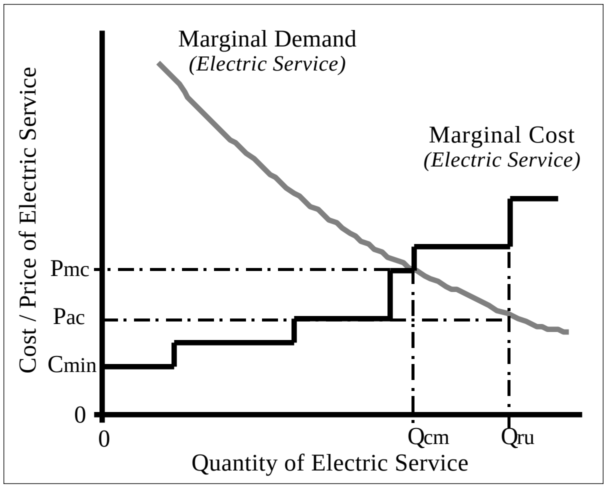

Figure 1: Competitive Pricing vs. Regulated Costs

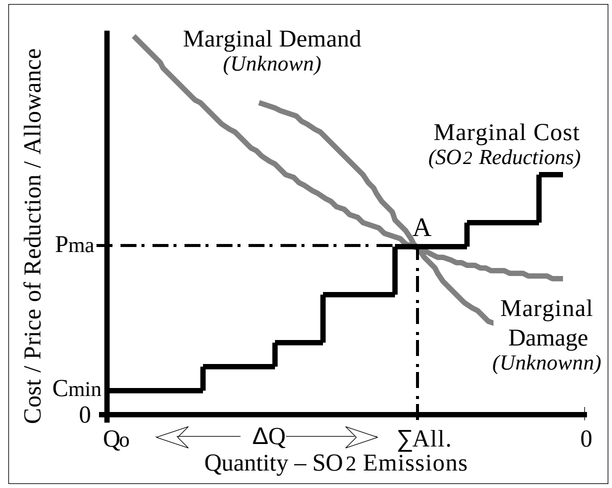

Figure 2: Cost-Effective SO_2 Emissions Reductions

commodity, accrues to the consumer. It is the consumer's surplus. As a consumer protection regulators utilize an approach better characterized as the "regulators' willingness-to-charge" rather than the "consumers' willingness-to-pay." This same approach also applies to environmental regulators as they seek out more cost-effective ways to achieve emissions reductions.

Cost Minimization and Environmental Regulation. The most innovative trend in environmental regulation is the use of tradable emission allowances and emissions offsets to achieve emissions reductions in the most cost-effective manner. Figure 2 shows the environmental analog to Figure 1's electric service cost regulation In this example, consumer's collective demand for electric service is replaced by environmental regulators' determination the quantity of allowable SO_2 emissions or allowances (∑All). Allowance trading ensures that the most cost-effective SO_2 reduction options are implemented, minimizing the cost of reducing emissions to ∑All. The setting of emission limits has traditionally been based upon expectations of impact thresholds, such that susceptible members of the population (asthmatic runners, emphysema sufferers, etc.) are protected. Use of direct health and environmental damage costs, or consumer's willingness-to-pay to avoid emissions have been absent in selecting these limits since reliable estimates of damages or risks of damage are not available, and therefore, the average consumer has no basis to make an informed assessment of his or her willingness-to-pay to avoid such damages.

With this in mind, we can clearly state that the level of emissions reduction, independent of the method by which it is met, does not reflect either society's willingness-to-pay for emissions reductions below the limit, or the environmental costs of those residual emissions. Furthermore, there is no basis to assume that regulators willingness-to-charge reflects society's willingness-to-pay, or that the willingness-to-charge, or pay, bears any direct analytical relationship to the environmental damage costs of residual emissions, even though substantive work has been conducted to identify the impacts of pollutant emissions.

Cost Minimization and Environmental Compliance. Both the trading of SO_2 allowances under Title IV, and the requirement for NO_x RACT and NO_x offsets under Title I of the 1990 Clean Air Act Amendments are superimposed upon prior environmental regulations affecting the emissions characteristics of (then) new generating sources. This introduces the additional complication of regulating a mature versus a growing infrastructure. The impact upon the cost-effectiveness of emissions reductions is illustrated in Figure 3. Units built after the original Clean Air Act had to meet New Source Performance Standards (NSPS). These standards required that the best technologically viable emissions control technologies be employed in new units (BACT, LAER)‡. State implementation plans for Title I–NO_x are relying upon BACT, RACT, and emissions offsets to achieve the desired NO_x reductions from stationary sources (ΔQ). BACT and LAER still apply to new generating sources, with NO_x offsets on a 1 to 1.2 ratio required for the units' residual NO_x emissions. RACT will apply to existing units by May 1995. Further emissions reductions might be required depending upon the effectiveness of these and other NO_x and VOC (Volatile Organic Compounds) controls for all sources.

What Figure 3 illustrates is that the oldest emission control regulations (BACT) are generally the most expensive, followed by NO_x RACT, which by definition pays more attention to the cost and cost-effectiveness of the measure. As the figure indicates, if environmental regulators are looking for an emissions reduction of ΔQ (Q_o - Qlim) then they are attaining it at ΔQ', fairly high up the schedule of cost-effective emissions reduction options. Offset requirements for new units, and to achieve additional NO_x reductions, will rely upon the offset market to the left of RACT before moving to higher cost technologies. One thing is clear, BACT technologies can in no way be considereda marginal cost of control since no market for emissions control technologies existed to select BACT as the last, most cost-effective option (thereby voiding use of

‡ RACT, Reasonably Available Control Technology. BACT, Best Available Control Technology. LAER, Lowest Achievable Emissions Rate.

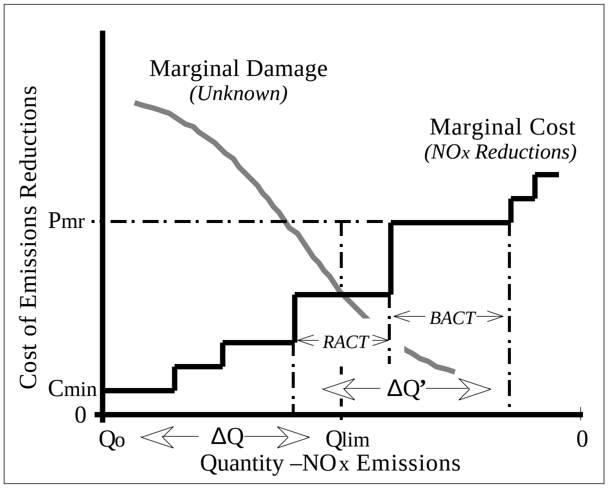

Figure 3: Command and Control Mixtures for NO_X

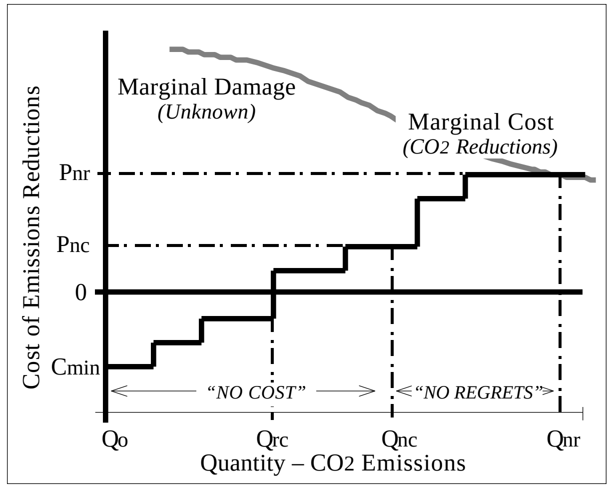

Figure 4: Identifying a "No-Regrets" Strategy for CO_2

the term "marginal"). Additionally, as this discussion illustrates, BACT technologies are in fact the first, least cost-effective options, not the last, most cost-effective ones, that labeling them as the marginal control would imply.Benchmarking an externality adder for residual NO_X emissions to NO_X BACT also provides poor information to utilities and regulators regarding the actual revenue, rate and emissions impacts of the decision. Supply curves, such as the one represented in Figure 3, are drawn to reflect the cost of supply controls to a given service territory, or specific population of power plants. Without knowledge of such a supply curve the cost and emissions implications of setting an adder at one level or another cannot even be estimated. To assess the impact of the Mass. DPU's original externality decision the Massachusetts Division of Energy Resources (Mass. DOER) commissioned a small independent study which concluded that the *maximum* impact upon rates (in 2006), resulting from the Mass. DPU's order was 6%. [6] Absent from the DOER's study was what this 6% increase represented in dollars ($), and avoided emissions (tons). Furthermore, the study assumed a static 75% capacity factor for the three comparative technologies, Coal FGD, Gas Combined-Cycle, and a "Completely Clean" resource, demand-side management (DSM) presumably. More detailed studies, using utility standard production-costing models, where new resources are dispatched within the population of available units according to their relative variable costs show that it is possible for "positive emissions" resources such as IGCC Coal and Gas Combined-Cycle to reduce total emissions more than DSM if they are more effective at displacing dirtier existing units. [7, 8]

RISK MITIGATION VS. SOCIAL COST ACCOUNTING

If we accept the regulatory paradigm of utility and environmental cost minimization, rather than welfare maximization, then discussions regarding the inclusion of external costs are more of the nature of "Social Cost Accounting" than "Economics." This being the case, quantification of external costs must focus primarily on their impacts and resulting opportunity costs, as opposed to their societal value or worth.

External vs. Unknown Environmental Costs. As stated before, and recently reaffirmed by the Massachusetts decision, insufficient information is currently available to complete the social cost equation. In fact, given the complexity of quantifying emission sources, fate, transport, impacts and resulting costs from emissions–today as well as in the future–it is unlikely that we will be able to calculate a relatively complete set of external costs anytime soon. However, as various health and environmental costs associated with utilities' residual emission become known they should be included in the resource planning process, converting direct costs from internal into "known" costs. Given that all the regulatory motivations for including even unknown environmental impacts in utility resource selection still hold, the appropriate strategy to follow is not one of minimizing (unknown) societal costs, but performing environmental risk management, identifying where emissions reductions can be had for free, or so inexpensively that incurring the (internal, known) costs to reduce them constitutes a "no-regrets" strategy.

NO-REGRETS STRATEGIES AND COST-EFFECTIVE EMISSIONS REDUCTIONS

Nowhere is the motivation to incorporate environmental concerns greater than with global climate change. Carbon Dioxide emissions are currently unregulated. Also, the climatalogical and economic impacts of anthropogenic greenhouse gas emissions are highly uncertain, with the likelihood that some will benefit and others will lose. Due to the issue's global nature, it is unlikely that the actions of a single country or industry will greatly affect the overall outcome. Yet we are compelled to act, and act prudently. Also, there is a growing body of evidence that there are substantial no-cost and low-cost options that may be implemented in the immediate future which can significantly reduce overall greenhouse gas emissions. Results from the National Academy of Sciences and the Intergovernmental Panel on Climate Change (IPCC) showed that between one and two billion tons of CO_2-equivalent greenhouse gas emissions can be avoided annually in the U.S. at effectively negative cost. [9] There are similar opportunities whether looking at New England [10], other countries [11], or internationally [12]. Figure 4 shows the implications of these studies for mitigating environmental risk via utility regulation.

Since the electric utility industry, like so many other industries, deals with issues that affect the age and efficiency of its generating stock and resource use patterns, the existence of an aging infrastructure means that there are technological and behavioral options which replace the worst of the old with the best of the new, at little or negative cost. Figure 4 illustrates this concept for CO_2. Detailed analyses for SO_2 and NO_x emissions in New England have shown similar results. In the figure there are options which reduce emissions from Q_o to Q_{rc} at with a *reduction* in electric service costs. Acquiring resources up to P_{nc} reduces emissions to Q_{nc} at no net-cost. Depending upon the relative risk or benefits perceived by regulators and other industry stakeholders, emissions can be reduced further, in the cheapest manner known, to a level that regulators deem prudent given the state of knowledge of environmental impacts. These "acceptable" costs to reduce emissions to Q_{nr} define a no-regrets strategy and regulators' *explicit* willingness-to-charge consumers to alleviate environmental risk.

INCREMENTAL RESOURCE CHOICE VS. INTEGRATED RESOURCE PORTFOLIOS

The preceding discussion should prompt the question, "Why don't we always reduce emissions to the "Reduced Cost" level (Q_{rc})?" Isn't the goal of integrated resource planning to identify and implement such strategies? As mentioned previously, and described in detail in [13], many such strategies require looking at how to increase the efficiency of the entire stock of resources (supply and demand), as well as picking the cleanest, most efficient additional resources. Utilities and regulators must deliberately explore options that displace aging existing generation, just as they upgrade the efficiency of existing building stock via demand-side management programs. Additionally, they should be looking for complementary options which reduce a series of emissions simultaneously, at little or no cost. Integrated resource planning must identify resource portfolios which seek to not only reduce known costs and emissions, but mitigate environmental risks as well as fuel cost, fuel availability, and operational uncertainties. Resource acquisitions must be interpreted as upgrading the existing system as well as acquiring the best available additional resource.

Uncertainties associated with cost recovery of existing rate base, as well as for the replacement unit, have inhibited both utilities and utility commissions from exploring a broader range of options. Potential ill will from attempting to site and license the replacement unit also contributes to existing generation being considered "sacred cows." A prime example of this, again, is the IRM process in Massachusetts where the prescribed externality adders (not to be confused health and environmental damage costs) are applied only to new proposed resources.

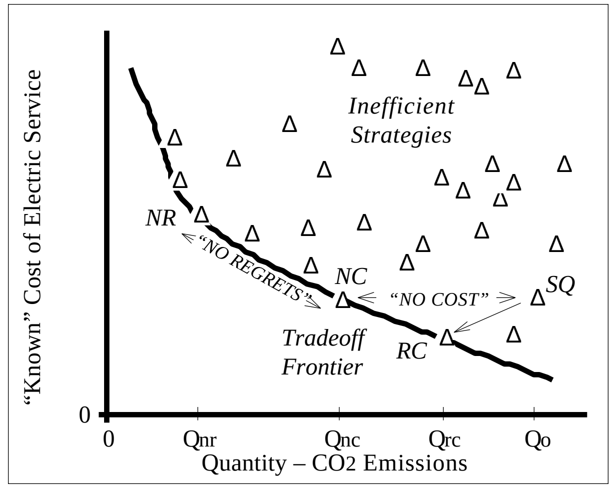

Figure 5: Moving to, and along the Tradeoff Frontier

IDENTIFYING EFFICIENT RESOURCE STRATEGIES USING TRADEOFF ANALYSIS

Moving to the Tradeoff Frontier. Figures 2 and 3 were drawn with no cost saving emissions reduction options. Top-down econometric models which fail to take into account the state of the existing infrastructure often yield such supply curves. Bottom-up analyses, such as production-costing models, often do a better job of incorporating the inefficiencies of the existing infrastructure (as depicted in Figure 4). (See Rubin for an example from the IPCC. [9])

Utility standard integrated resource planning tools don't normally yield supply-curves for reducing specific emissions. What they normally yield are a range of attributes such as costs, emissions, or unmet energy which describe the performance of the electric power system when following a specific resource strategy. Comparative analysis of competing resource strategies can be easily performed for a broad range of attributes using scatterplots (colloquially referred to as tradeoff graphs). On a tradeoff graph the axes represent the performance attributes, and the performance of each strategy is represented by a symbol located on the graph. Figure 5 illustrates such a graph. As can be seen, there is a set of strategies for which there are no strategies with both lower costs *and* CO_2 emissions. In this example strategies which lie closest to the lower left corner are those with the lowest cost and CO_2 emissions. These strategies along the tradeoff frontier compromise the "decision set," and each strategy represents the most-efficient way to achieve a given level of emissions reduction.

Referring back to Figure 4, acquisition of those resources to the left of Q_{rc} reduce both electric service costs and CO_2 emissions. In Figure 5, this is represented by the changes in cost and emissions between strategy SQ (Status Quo–additional resources only) and strategy RC (Reduced Cost), situated along the tradeoff frontier. Without any further consideration of emissions, the least-known-cost strategy resides on the "high emissions" tail of the tradeoff curve.

Moving along the Tradeoff Frontier. Choosing to follow strategy NC (No Cost) rather than SQ, moves industry performance to the tradeoff frontier as well, but here utility industry decisionmakers have chosen to incur the cost increase from RC to NC to attain a CO_2 reduction of Q_{RC}-Q_{NC}. If regulators believe this reduction is sufficient given the uncertainties surrounding the possible impacts of climate change, then NC may be considered the "no-regrets" strategy. If not, another strategy up the tradeoff curve, such as NR may be selected, redefining the costs regulators are willing-to-charge to further reduce environmental risk.

What magnitude of costs and emissions reductions do we face when deciding where along the tradeoff curve to aim? The costs of moving along the tradeoff curves for cost vs. SO_2, NO_x and CO_2 emissions in New England are discussed in detail in [14]. A more complete explanation of the strategies evaluated is covered in [13]. These analyses found that strategies which focused on upgrading the efficiency of fossil generation (predominantly via repowering with natural gas combined-cycle) and end-use consumption (via aggressive conservation), populated the tradeoff frontiers. In summary, for a modest load growth forecast there were strategies which for a 1.05% increase in twenty-year (undiscounted) revenue requirements (including customer contributions to DSM), reduced SO_2 emissions by over 51% from a 20 year Clean Air Act Allowance approximation, reduced NO_x emissions by 24% from a constant 1989 level 20 year emissions baseline, and reduced CO_2 emissions by greater than 16% from a similar 1989 emissions baseline. How to integrate decisions made using tradeoff analysis into utility's competitive bidding processes like the IRM is discussed in [15].

CONCLUSION

While utility regulators' motivations for including external environmental costs in utility resource planning are valid, and the microeconomic theory surrounding the societal costs fundamentally sound, regulatory actions which rely upon willingness-to-pay proxy measures for external costs break fundamental economic principles and regulatory goals by equating consumer value with consumer cost. Moreover, since quantification of health and environmental damages from residual emissions is a complex and difficult task, a relatively complete set of reliable damage cost estimates are unlikely to appear for some time. With this realization, utility regulators' efforts should be aimed more at mitigating environmental risk than completing the social cost equation

Over the last decade regulatory strategies of both utility commissions and environmental agencies have focused on implementing the least expensive, and therefore most cost-effective, electric service and emissions control options available. Use of existing integrated planning and analytic tools can further these efforts if they are employed to examine existing as well as new resources to formulate complementary resource strategies that ensure that environmental and other goals are met at least-known-cost.

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