

**Literature review on *ex-post* assessment of costs to business of environmental policies and legislation**

**Final version, September 2005**

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This report was commissioned by: European Commission, DG Environment, Unit G.1  
Sustainable Development & Economic Analysis, under a framework contract No  
ENV.G.1/FRA/2004/0081.

The contents and views contained in this report are those of the authors, and do not  
necessarily represent those of the European Commission.

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## Introduction

This paper is the output of the first task in the framework of a study to provide *ex-post* estimates of (net) costs to business of selected pieces of EU environmental legislation. This study was commissioned by the European Commission (DG Environment) under the Framework Contract on Economic Analysis in the Context of Environmental Policies and of Sustainable Development.

The current paper was prepared by IVM and Ecologic, with contributions from other consortium partners (BIO, GHK, PSI, TME and VITO). Part I contains a broad survey of relevant publications that were identified, with short descriptions of their content. A number of publications, which were considered to be the most relevant for the current study, were summarised. These summaries can be found in Part II.

## Main findings

Although the literature contained in the review is very diverse in terms of subject, approach and geographical coverage, some general conclusions can be derived from this survey tentatively:

- There is no uniform concept of costs being applied when estimating costs of environmental policy to business. For instance, the demarcation of system boundaries varies from case to case. Furthermore, costs of externalities are sometimes, but not always, taken into account. Equally, different discount, interest and exchange rates, and accounting procedures are applied.
- The *ex ante* estimated costs of a technology (to be applied as a result of the new policy) often do not take into account economies of mass production. Often costs are calculated for new, prototype technologies.
- The policy ultimately adopted is not necessarily the same as the one for which the costs were estimated.
- The implementation of the policy might be incomplete. Moreover, the way in which the policy or legislation is implemented and the instruments chosen (e.g. market based instruments *versus* direct regulation) strongly affect the *ex post* costs.
- The potential for innovation and efficiency improvements (including substitutes) is often underestimated or neglected by the companies when estimating *ex ante* costs.
- There are only few examples for *ex-post* costs to be higher than *ex-ante* estimates. Anecdotal evidence indicates that costs of the public projects, such as waste water treatment plants, tend to be underestimated, whereas costs of compliance for private companies might be overestimated.



## I. List of surveyed studies

**NB: Publications with grey background are summarised in Part II.**

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
ADEME	Etude des coûts 2001 de la collecte sélective et du tri des ordures ménagères recyclables	2002	Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME), Direction des Déchets Municipaux, december 2002	Includes a comprehensive cost model for various waste management options, more than 40 case studies of collection systems and plants in France, and comparisons of ex-ante and ex-post costs
AEA Technology	Economic Evaluation of Proposals for Emission Ceilings for Atmospheric Pollutants	1999	<a href="http://www.aeat.co.uk">http://www.aeat.co.uk</a>	Ex post effects of CO2 emissions reduction policy on the automotive industry
AEA Technology	Options to Reduce Nitrous Oxide Emissions	1998	<a href="http://europa.eu.int/comm/environment/enveco/climate_change/nitrous_oxide_emissions.pdf">http://europa.eu.int/comm/environment/enveco/climate_change/nitrous_oxide_emissions.pdf</a>	Cross-measure comparison of N2O emission-reducing technology (also cross-countries), discusses cost-effectiveness ex post, but effectiveness ex ante
AEA Technology	Service Contract for "Ex post" Evaluation of Short-term and Local Measures in the CAFE context.	2003	Proposal to the European Commission, DG Environment, ENV.C.1/SER/2003/0061	Proposal for a Service Contract to DG Environment on the development of a database tool to hold information on short term and local measures on air quality in Europe. Database tool will include information on effectiveness, costs and benefits.
Andersen, M.	Effectiveness of Waste Water Policies in Selected Countries – an EEA pilot study	2004	Unpublished as yet, <a href="http://www.dmu.dk/International">http://www.dmu.dk/International</a>	Ex-post, cross-country comparison of government run waste water plants, depending on the level of implementation of EU policy
Anderson, J.F., and T. Sherwood	Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes	2002	Presented at the SAE Government Industry meeting, Washington DC, May 14th 2002 2002-01-1980	This paper compares directly ex-ante and ex-post costs for the 1990 Clean Air Amendments in the US. It compares ex-ante costs generated by the industry and EPA with actual ex post cost.
Bailey, P.D.,	Mind the gap! Comparing <i>ex ante</i>	2002	European Environment 12 (5), p. 245-256	Comparison of ex post ex ante for businesses.

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
<i>et al.</i>	and <i>ex post</i> assessments of the costs of complying with environmental regulation			Suggests that discrepancies result from differences in behavior, implementation processes & new technological solutions
Beamont, N. and Tinch, R.	Cost Effective Reduction of Copper Pollution in the Humber Estuary	2004	CSERGE Working Paper ECM 03-04, CSERGE, University of East Anglia, UK <a href="http://www.uea.ac.uk/env/cserge/pub/wp/ecm/ecm_2003_04.pdf">http://www.uea.ac.uk/env/cserge/pub/wp/ecm/ecm_2003_04.pdf</a>	No ante/post comparison per se, but a cross-measure comparison of the costs & benefits of several companies' copper pollution abatement techniques (single watershed)
Burtraw, D.	The SO <sub>2</sub> Emissions Trading Program: Cost Savings Without Allowance Trades	1996	Contemporary Economic Policy 14 (2), April 1996, p. 79-94.	Tries to explain the difference between ex ante estimates of SO <sub>2</sub> emission reduction (industry: \$ 1500 per tonne; EPA: \$ 750 per tonne) and the actual prices of emission allowances on the market (between \$100 and \$ 170 in 1995). Unexpected availability of low-sulfur coal at low cost and innovations in scrubber technology are among the explanatory factors.
Cagnot, J.-F., V. Monier and A. le Doré	Cost-efficiency of packaging recovery systems	2000	Taylor Nelson Sofres Consulting, Final Report for European Commission, DG Enterprise, February 2000, <a href="http://europa.eu.int/comm/enterprise/environment/reports_studies/studies/study00cost-eff_sofres_502038.pdf">http://europa.eu.int/comm/enterprise/environment/reports_studies/studies/study00cost-eff_sofres_502038.pdf</a>	Contains an extensive literature review, an evaluation of ex-post costs (detailing investment and operating costs as well as revenues) of packaging waste management systems and in-depth analyses for 4 countries (France, Germany, Netherlands and UK)
CBS	Milieukosten elektriciteitscentrales	2005	Centraal Bureau voor de Statistiek, Voorburg	
CERNA	The Implementation of the Municipal Waste Incineration Directives	2000	Centre d'Économie Industrielle (CERNA), École Nationale Supérieure des Mines de Paris <a href="http://www.cerna.ensmp.fr/Progeuropeens/IMPOL/publi.html">http://www.cerna.ensmp.fr/Progeuropeens/IMPOL/publi.html</a>	NOT businesses, but a cross-country ex post comparison of cost-effectiveness of EU legislated waste incineration devices
Clinch, J., Kerins, D.	Assessing the Efficiency of Integrated Pollution Control Regulation	2002	European Environment 12 (5), p. 269-283	Ex post compliance costs are reduced if specific factors of each business are taken into account (flexible regulations)

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
Dowlatabadi, H.	What do we know about climate policy costs and how can we learn more?	2003	Organization for Economic Co-operation and Development, <a href="http://www.oecd.org/dataoecd/9/57/2482300.pdf">http://www.oecd.org/dataoecd/9/57/2482300.pdf</a>	Ch. 3, p. 13 comparison of ex ante and ex post for industries– how to strengthen regulations, most ex ante overestimate the cost
Dijkmans, R.	Methodology for selection of Best Available Techniques (BAT) at the sector level	2000	Journal of Cleaner Production 8 (1), p. 11-21	A methodology is described that allows expert judgement on BAT in a straightforward and transparent way. Central to this methodology are scores given on technical feasibility, on cross media environmental performances and on economic feasibility. The practicality of this approach was shown in 10 BAT studies of which 2 (vehicle finishing and manure processing) are discussed in
Eames, M. <i>et al</i>	The Implementation of EMAS in Europe: a case of competition between standards for environmental management systems	2000	SPRU – Science and Technology Policy Research, University of Sussex, <a href="http://www.cerna.ensmp.fr/Progeuropeens/IMPOL/publi.html">http://www.cerna.ensmp.fr/Progeuropeens/IMPOL/publi.html</a>	Ex post data in cross-country, company participation in EMAS is voluntary so participation is low, but the study recommends methods of enticement
Eames, M.	The Large Combustion Plant Directive (88/609/EEC): an effective instrument for SO <sub>2</sub> pollution abatement?	2001	In: “Implementing European Environmental Policy: the impacts of the Directives in Member States”, M, Glachant (ed.), Edward Elgar, p. 59-98	Compares implementation of LCP requirements for existing plant (only SO <sub>2</sub> ) in Germany, Netherlands, France and UK. Qualitative cost-effectiveness assessment; no comparison with ex-ante cost estimates.
Ecotec and GHK	A Study to Evaluate Cost Estimates of Specific Measures Associated with the National Air Quality Strategy	2002	A Final Report to DEFRA, C1966, April 2002	This paper provides some ex-ante and ex-post costs. It explores the reasons for the differences and would therefore be useful in informing the methodological paper.
Ellerman, A.	Ex Post Evaluation of Tradable Permits: The U.S. SO <sub>2</sub> Cap-and-Trade Program	2003	Massachusetts Institute of Technology, <a href="http://web.mit.edu/ceepr/www/2003-003.pdf">http://web.mit.edu/ceepr/www/2003-003.pdf</a>	Ex post analysis of sulphur dioxide emissions trading, also provides comparison with ex ante estimates for same policy measures
Eunomia	Costs for Municipal Waste	2001	<a href="http://europa.eu.int/comm/environment/waste/s">http://europa.eu.int/comm/environment/waste/s</a>	Concludes that collection costs for residual waste

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
Research & Consulting Ltd	Management in the EU		tudies/eucostwaste.pdf	per household are not very different across the Member States, but costs per tonne are (probably reflecting the fact that some Member States are more successful than others in terms of rates of source separation). Costs of collection and treatment also differ widely, mainly due to economies of scale.
European Commission, Standard & Poor's DRI and K.U. Leuven	Auto-Oil II Cost-effectiveness study	1999	<a href="http://europa.eu.int/comm/environment/enveco/auto-oil/index.htm">http://europa.eu.int/comm/environment/enveco/auto-oil/index.htm</a>	Cost-effectiveness analysis of the Auto Oil II programme, using the TREMOVE model
European Commission	Implementing the Community Strategy to Reduce CO2 Emissions from Cars: First annual report on the effectiveness of the strategy	2000	<a href="http://europa.eu.int/eur-lex/en/com/pdf/2000/act0615en03/1.pdf">http://europa.eu.int/eur-lex/en/com/pdf/2000/act0615en03/1.pdf</a>	Broad study of effects of air pollution reduction policy on international trade (US, EU), including effects on industry in terms of trade and competitiveness
European IPPC Bureau	Reference document on economics and cross-media effects	2005	European IPPC Bureau, Sevilla (version adopted by the European Commission)	Presents in chapter 3 some guidelines on how to deal with cost data and ex-ante cost calculations when determining BAT. The guidelines allow the user to set the costs transparently, so that the BAT-options can be validated, audited and compared in an equitable way.
Finnish Environment Institute	Evaluation of environmental policy instruments: A case study of the Finnish pulp & paper and chemical industries	2002	Monographs of the Boreal Environment Research No. 21, p. 134. <a href="http://www.ymparisto.fi/default.asp?contentid=67829&amp;lan=en">http://www.ymparisto.fi/default.asp?contentid=67829&amp;lan=en</a>	Effects of different environmental regulations on businesses in terms of innovations, management responses etc.; little evidence on costs
Glachant, M.	How can the Implementation of EU Environmental Policy be more	2000	CERNA research report 2000-B-7	Although the factors determining cost for implementation of the plants differs greatly between

<b>Author(s)</b>	<b>Title</b>	<b>Year</b>	<b>Publisher, journal, report no. etc.</b>	<b>Short description</b>
	Effective and Efficient?			countries, actual cost is similar – room for improvement
Goodstein, E., and H. Hodges	Polluted Data	1997	American Prospect No.35, November-December 1997	Compares predicted cost estimates with actual costs for various environmental and occupational safety and health regulations: on asbestos, benzene, CFCs, coke ovens, cotton dust, halons, strip mining, and vinyl chloride. In all cases but one, the initial estimates were at least double the actual costs.
Gouldson, A., and J. Murphy	Regulatory realities - The implementation and impact of industrial environmental practice	1998	Earthscan, London	Thorough ex post analysis of the effects of various regulations on industries
Hahn, R.	The Impact of Economics on Environmental Policy	1999	AEI-Brookings Joint Center for Regulatory Studies, Working Paper 99-4, <a href="http://www.aei-brookings.org/admin/authorpdfs/page.php?id=85">http://www.aei-brookings.org/admin/authorpdfs/page.php?id=85</a>	Historical evaluation of how economic tools affect policy-makers' choices and industries' options, including a table of <i>ex ante</i> and/or <i>ex post</i> estimates of cost savings for five tradable permit programs for air pollution control.
Hammitt, J.K.	Are The Costs of Proposed Environmental Regulations Overestimated? Evidence from the CFC Phaseout	2000	Environmental and Resource Economics 16, p. 281-301	Evaluates the accuracy of <i>ex ante</i> predictions using <i>ex post</i> calculations of costs to industries resulting from CFC-limiting measures
Haq G et al.	Determining the costs to industry of environmental regulation.	2001	European Environment 11 (3), p. 125–139.	Paper provides an overview of the cost of compliance with environmental regulation by considering the arguments, strategies and cost estimates that were presented by industry during the negotiations of different environmental regulations. [Largely identical with SEI 99]
Harrington, W., and McConnell,	The Enhanced I/M Program in Arizona: Costs, Effectiveness, and a Comparison with Pre-regulatory	1999	By Resources for the Future for client: US EPA, <a href="http://www.rff.org">http://www.rff.org</a>	Ex post survey of the cost of implementing new Arizona automobile emissions regulations: greater than EPA's <i>ex ante</i> assessment

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
V., Ando, A.	Estimates			
Harrington, W., R. Morgenstern and P. Nelson	On the Accuracy of Regulatory Cost Estimates	2000	Journal of Policy Analysis and Management, Vol. 19, No. 2, 297–322 (2000) (also published as Discussion Paper 99-18, Resources for the Future, January 1999)	Comparison between ex ante and ex post assessments for industry compliance show that ex ante estimates are usually high
Harrington, W., R. Morgenstern and Th. Sterner (eds.)	Choosing Environmental Policy: Comparing Instruments and Outcomes in the United States and Europe	2004	Resources for the Future	Compares the use of different policy instruments in the USA and European countries for similar environmental policy problems.
Hitchens, D., <i>et al.</i>	The impact of Best Available Techniques (BAT) on the competitiveness of European industry	2001	JRC/IPTS, for DG Enterprise EUR 20133 EN	Comparative ex post performance among 3 industries (cement; pulp and paper; non-ferrous metals), some using BAT, some not. The findings of the study show that plants that have already adopted BAT and achieve a good environmental performance are viable in the long run. This result is in line with other reports on this issue [e.g. Gouldson, 1998].
IIASA and AEA Technology	Economic Evaluation of a Directive on National Emission Ceilings for Certain Atmospheric Pollutants (part A)	1999	For DG Environment <a href="http://europa.eu.int/comm/environment/enveco/air/cost-effectiveness.pdf">http://europa.eu.int/comm/environment/enveco/air/cost-effectiveness.pdf</a>	Cost-effectiveness analysis of emission reduction scenarios for SO <sub>2</sub> , NO <sub>x</sub> and VOCs, using the RAINS model
International Chemical Secretariat	Cry wolf – predicted costs by industry in the face of new regulations	2004	Report 6:04, International Chemical Secretariat, Göteborg	In response to industry claims that the costs of the proposed REACH legislation will be exorbitantly high, this paper shows how <i>ex ante</i> costs of environmental legislation have been systematically overestimated in the past. It is mainly based on SEI (1999), Goodstein and Hodges (1997) and Harrington <i>et al.</i> (2000).

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
Jacobsen, H.	Analysis of effectiveness of implementing packaging waste management systems	2004	Grey study, European Topic Centre on Waste and Material Flows	Ex post cross-country study on the effectiveness of packaging waste management systems
Jantzen, J.	Kosten van het milieubeheer 1985-2010	1989	Ministerie van VROM, Publicatiereeks milieubeheer 89/5	Ex ante assessment of Dutch environmental policies; can be compared with realisation as reported by RIVM/MNP in its annual
Joosen, S., Harmelink, M., Blok, K.	Evaluatie van het Klimaatbeleid in de Gebouwde Omgeving 1995-2002	2004	Ecofys, EEP03007	Impact evaluation of Dutch climate policy with respect to buildings in the period 1995-2002.
Krozer, J.	Milieu en innovatie	2002	PhD thesis, Groningen University	Contains 28 empirical emission reduction cost functions for individual substances and groups of substances and analyses the role of innovation in reducing compliance costs. No direct link with EU
Labouze, E., and V. Monier	Impact Assessment on Selected Policy Options for Revision of the Battery Directive	2003	BIO IS for DG Environment A2	Contains a.o. (ex post) cost assessments of different management practices for spent batteries in various MS (Austria, Belgium, France, Germany, Netherlands, Denmark).
McMahon, P.	Cost of Compliance Assessment and the Water Industry in England and Wales	2002	European Environment 12, p. 257-268	Periodic ex post CCA's (compliance cost assessments) of water companies
Milieu Ltd.	Comparison of the EU and US approaches towards acidification, eutrophication and ground level	2004	<a href="http://www.milieu.be">http://www.milieu.be</a>	Automobile fuel efficiency, comparison of the cost-effectiveness of several strategies
Milieu, NERI, CCAP	Assessment of the Effectiveness of European Air Quality Policies and Measures	2004	Final Report, B4-3040/2003/365967/MAR/C1	Three case studies on the comparison of EU and US approaches to air quality problems.
Ministerie van VROM	Kosten en baten in het milieubeleid: definities en berekeningsmethoden	1998	Dutch Ministry of Environment (VROM), Publicatiereeks Milieustrategie 1998/6, The	Intended to put an end to the discussions on how to determine environmental costs for firms.
Monier, V.,	Critical Review of Existing Studies	2001	Hayler Nelson Sofres Consulting & BIO IS for	Contains a.o. (ex post) cost assessments of different

<b>Author(s)</b>	<b>Title</b>	<b>Year</b>	<b>Publisher, journal, report no. etc.</b>	<b>Short description</b>
and E. Labouze	and Life Cycle Analysis on the Regeneration and Incineration of Waste Oils		DG Environment A2	management practices for waste oils in various MS (Belgium, France, Germany, Italy, Spain, UK)
NN	Economic consequences of the IPPC Directive – summary and conclusions	2002	DG Enterprise Workshop, Brussels, May 2002	Summarises discussions held at the workshop, a.o. about assessing the <i>ex post</i> economic impact of BAT.
Pearce, D. and I. Brisson	BATNEEC: the economics of technology based environmental standards, with a UK case	1993	Oxford Review of Economic Policy 9 (4), p. 24-40	Describes the economics of technology-based standards in general and of BATNEEC in particular.
Pickman, H.A.	The effect of environmental regulation on environmental innovation	1998	Business Strategy and the Environment 7 (4), p. 223-233	Policy based on ex ante predictions overestimates the cost of regulations (ex ante/post US manufacturing industry comparisons)
Pizer, W.A., and R. Kopp	Calculating the Cost of Environmental Regulation	2003	Resources for the Future, Discussion Paper 03-06, March 2003	Presents a taxonomy of the costs of environmental regulation, along with methods for measuring those costs.
RDC-Environment & Pira International	Evaluation of costs and benefits for the achievement of reuse and recycling targets for the different packaging materials in the frame of the packaging and packaging waste directive 94/62/EC	2003	<a href="http://europa.eu.int/comm/environment/waste/studies/packaging/costsbenefits.pdf">http://europa.eu.int/comm/environment/waste/studies/packaging/costsbenefits.pdf</a>	Applies CBA to a number of packaging materials and packaging waste management options, in order to determine 'optimum' recycling and reuse rates.
Resources for the Future	The Chesapeake Bay and the Control of NOx Emissions: A Policy Analysis	1998	<a href="http://www.rff.org/Documents/RFF-DP-98-46.pdf">http://www.rff.org/Documents/RFF-DP-98-46.pdf</a>	Ex-ante Comparison of the costs/benefits of various pollution deterring policy tools based on general equilibrium models
Resources for the Future	The Cost-Effectiveness of Alternative Instruments for Environmental Protection in a	1998	<a href="http://ideas.repec.org/a/eee/pubeco/v72y1999i3p329-360.html">http://ideas.repec.org/a/eee/pubeco/v72y1999i3p329-360.html</a>	Ex post analysis of NOx reduction in US businesses – comparison by duration and geographical scope of the policy implementation
Resources for the Future	The cost-benefit of environmental protection	1998	RFF Discussion Paper 98-36	Explores the relationship between reported environmental expenditures and economic cost in

<b>Author(s)</b>	<b>Title</b>	<b>Year</b>	<b>Publisher, journal, report no. etc.</b>	<b>Short description</b>
				large US manufacturing plants
Resources for the Future (with AEA)	Retrospective Examination of Demand-Side Energy Efficiency Policies	2004	<a href="http://www.rff.org/rff/Documents/RFF-DP-04-19REV.pdf">http://www.rff.org/rff/Documents/RFF-DP-04-19REV.pdf</a>	Some ex post evaluation of actual cost of several greenhouse gas reduction strategies
Rijksinstituut voor Volksgezondheid en Milieu (RIVM)	Kosteneffectiviteit van milieumaatregelen (Cost effectiveness of environmental measures)	2000	RIVM rapport 773008002, <a href="http://www.rivm.nl/bibliotheek/rapporten/773008002.pdf">http://www.rivm.nl/bibliotheek/rapporten/773008002.pdf</a>	Calculates ex ante cost-effectiveness curves for acidic air pollutants
RIVM	Quick scan effectiviteit en doelmatigheid van het natuurbeleid (Quick scan effectivity and efficiency of the nature policy in the Netherlands)	2002	<a href="http://www.rivm.nl/bibliotheek/rapporten/408765001.pdf">http://www.rivm.nl/bibliotheek/rapporten/408765001.pdf</a>	Comparison of ex ante and ex post cost of nature policy instruments
Söderbaum, P.	Issues of Paradigm and Ideology in <i>ex ante</i> and <i>ex post</i> Evaluation	2004	School of Business, Mälardalen University	How to use ex post techniques to improve ex ante predictions – more theory than practical application to industry
Sperling, D., et al.	Analysis of Auto Industry and Consumer Response to Regulations and Technological Change, and Customization of Consumer Response Models in Support of AB 1493 Rulemaking	2004	Institute of Transportation Studies, University of California, Davis, for the California Air Resources Board and the California Environmental Protection Agency UCD-ITS-RR-04-17	Analyses industry and consumer response to government regulations in the area of vehicle safety and emissions, using data from the US and Europe for the period 1975-2003. Case studies on catalytic converters (US), air bags (US), diesel cars (Europe) and hybrid electric vehicles (US).
Stockholm Environment Institute (SEI)	Costs and Strategies presented by Industry during the Negotiation of Environmental Regulations	1999	SEI, Stockholm	Ex post results of collaboration between industries and governmental bureaus in improving air quality by limiting oil use
TME	Technische vooruitgang en milieukosten	1995	TME, Den Haag	Shows that the costs of environmental equipment decrease as a function of time, due to technological

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
				development. Examples are the removal of phosphates from waste water; desulphurisation at power stations; catalytic converters for passenger cars; and low-NO <sub>x</sub> technologies in industry.
TME	Kiezen voor winst	1997	TME, Den Haag	Shows that cost advantages of tradable permits for NO <sub>x</sub> (in large industries) can be as large as 50% of initial cost estimates for a regulatory approach.
TME	Milieukostenramingen t.b.v. Milieubalans 2005	2005	TME, Nootdorp	Shows that <i>ex ante</i> cost estimates for air pollution control in Dutch power plants are much higher than realised costs, whereas for refineries the <i>ex ante</i> and <i>ex post</i> costs are more similar.
US EPA	Cost-Effectiveness Analysis Of Proposed Effluent Limitations Guidelines And Standards For The Centralized Waste Treatment Industry	1995	<a href="http://yosemite.epa.gov/water/owrcatalog.nsf/0/b0c7c99f6e0bab5285256b0600723349?OpenDocument">http://yosemite.epa.gov/water/owrcatalog.nsf/0/b0c7c99f6e0bab5285256b0600723349?OpenDocument</a>	Ex-ante assessment of Cost-effectiveness of water pollution control in the Great Lakes, comparison of techniques & a case study
Van Grinsven, H., Van Eerdt, M., Willems, J., Mulleneers,	Evaluation of the Dutch Manure and Fertiliser Policy, 1998-2002	2004	Through the Dutch Ministry of Agriculture, Nature and Food Quality (EC-LNV)	Requisite (by statute) biannual evaluation of the Dutch Fertilisers Act – totally <i>ex ante</i> – costs are compared to reductions in manure emissions
Verein Deutscher Ingenieure	Determination of costs for industrial environmental protection measures	2001	VDI Richtlinie 3800	Guideline for determining environmental costs for firms
Vercaemst, P.	BAT: when do Best Available Techniques become Barely Affordable Technology?	2002	Paper for the workshop ‘The economic consequences of the IPPC-Directive’, European Commission, Brussels, May 16,	Presents some ideas on how to carry out an economic evaluation of candidate-BAT.
Vercaemst, P.	Costing methodology for BAT	2001	2002 Paper as input for the horizontal BREF on	Presents a method for determining the costs of BAT.

<i>Author(s)</i>	<i>Title</i>	<i>Year</i>	<i>Publisher, journal, report no. etc.</i>	<i>Short description</i>
	purposes		Economics and cross-media issues, Vito, 2001	
Watkiss, P., <i>et al.</i>	A Comparison of EU Air (Quality) Pollution Policies and Legislation with Other Countries	2004	AEA Technology Environment and Metroeconomica, for DG Enterprise	Evaluation of IMPOL (Implementation of EU Environmental Policy), ex ante impacts of implementation of pollution abatement costs
Westhoek H, van den Berg R, de Hoop W, van der Kamp A.	Economic and environmental effects of the manure policy in The Netherlands: synthesis of integrated ex-post and ex-ante evaluation	2004	Water Science and Technology 49 (3), p. 109-116	Summarises a.o. the results of an ex-post evaluation of the Dutch Mineral Accounting System (MINAS). The MINAS system was introduced in 1998 in order to reduce nitrate and phosphate leaching from agricultural soils. MINAS resulted in a reduction of the N surplus on dairy farms of approximately 50 kg/ha at limited or no costs to the farms involved. MINAS resulted in higher costs for manure removal for intensive livestock farmers.
Williams, E., Macdonald, K., Kind, V.	Unravelling the Competitiveness Debate	2002	European Environment 12 (5), p. 284-290	General discussion on the effects of environmental regulation, compliance costs on business competitiveness
WRc	Study on investment and employment related to EU policy on air, water and waste	2000	European Commission, DG Environment WRc Ref.: EC 4739/M/11452-0 September 2000	Estimates costs and employment effects associated with ten major directives in the areas of air, water and waste
Wright, Millichamp and Buckland	The Cost-Effectiveness of Reductions in Dioxin Emissions to Air from Selected Sources	2001	<a href="http://www.mfe.govt.nz/publications/hazardous/dioxin-reduction-cost-effectiveness-aug01.pdf">http://www.mfe.govt.nz/publications/hazardous/dioxin-reduction-cost-effectiveness-aug01.pdf</a>	Ex post costs of reducing dioxin emissions much greater than ex ante predictions, making accelerated compliance deadlines harder to enforce
Wynn, G.	The cost-effectiveness of biodiversity management: a comparison of farm types in extensively farmed areas of Scotland.	2002	<a href="http://www.mluri.sari.ac.uk">http://www.mluri.sari.ac.uk</a>	Ex post, cross-measure comparison of the cost effectiveness of various grazing schemes



## II. Summaries of selected literature

Author	Anderson, J.F., and Sherwood, T.
Title	Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes
Year	2002
URL	
Reference	Presented at the SAE Government Industry Meeting, Washington, DC, May 14, 2002
Summary	The US Clean Air Act (CAA) Amendments of 1990 stimulated a substantial number of new regulations for highway vehicles and their fuels. Among the issues of contention in many of those rules was the cost likely to result from new standards. EPA estimates of the expected cost of new rules were significantly lower than estimates by other stakeholders. To help assess the accuracy of various estimates, this study develops a comparison of <i>ex ante</i> cost estimates with actual <i>ex post</i> price changes. The general pattern that is revealed indicates that all <i>ex ante</i> estimates tended to exceed actual price impacts, with the EPA estimates exceeding actual prices by the smallest amount.
Methodology	Two groups of regulations were examined using two different approaches. <ol style="list-style-type: none"> <li>1. Regulations concerning individual fuel quality (affecting gasoline and diesel): for these rules the authors were able to compile data on price differentials for the various new fuel grades required. This allowed a straightforward comparison between <i>ex ante</i> and <i>ex post</i> data.</li> <li>2. Rules for light-duty passenger cars: price data for this group of rules was not available disaggregated by each individual regulatory program. Using information on total price impacts from all CAA requirements arrayed by calendar year, the authors were able to make a successful comparison with estimated rule costs for rules taking effect in those calendar years.</li> </ol>
Results	<ol style="list-style-type: none"> <li>1. Almost all <i>ex ante</i> costs estimates of fuel regulations exceeded the actual price changes. Cost estimates by industry stakeholders exceeded actual prices by the largest amounts, by ratios ranging from nearly 2:1 to 6:1.</li> <li>2. For the EPA vehicle emission control programs, accumulated EPA cost estimates exceeded actual price changes by approximately \$ 100 per vehicle, while the cumulative manufacturer estimate was nearly \$ 500 above actual.</li> </ol>

Author	Bailey, P. D., <i>et al</i>
Title	Mind the gap! Comparing <i>ex ante</i> and <i>ex post</i> assessments of the costs of complying with environmental regulation
Year	2002
URL	<a href="http://www.interscience.wiley.com">http://www.interscience.wiley.com</a>
Reference	European Environment 12, 245-256 (2002)
Summary	<p>This paper considers the question of how ex-ante predictions of the costs of complying with environmental regulations compare with ex-post evaluations of actual compliance costs.</p> <p>This is an important issue given the conclusion of previous research that the predicted costs of compliance with environmental regulations often exceed actual costs (see Haq et al., 2001). Based upon a review of the different stages of the regulatory decision-making process, this paper suggests that the reasons for these differences relate to strategic behaviour by affected parties in the policy formulation stage, problems in anticipating the influence of the implementation process, difficulties in forecasting the availability of new technological solutions and incentives for firms to reduce the costs of compliance once environmental regulations have been adopted.</p>
Methodology	Findings are based on evidence from the empirical literature, including Haq et al. 2001, Harrington et al. 2000, Krewitt et al. 1999.
Results	<p>Ex-ante estimates are generally bound to overestimate costs as analysed ex-post because of the behaviour of actors (regulation creator, regulation enforcer and regulated party) in all phases of the policy process:</p> <ol style="list-style-type: none"> <li>1) <u>Policy-making</u>: Negotiation of possible policy options to deal with an identified problem. This is typically the stage at which ex-ante evaluation would take place. Firms conduct their own research which usually shows higher costs than anticipated, since firms have more knowledge of their business activities than the regulator (information asymmetry). Policy makers (influenced by both science and politics) take excessive precautions rather than risks where the effect is uncertain and the data incomplete.</li> <li>2) <u>Regulation development</u>: Once the regulation has been agreed, firms will begin to engage with the implementation process to ensure that the policy is interpreted and applied in a way that reflects their interests. "Regulatory capture" occurs when regulatory bodies become sympathetic to the entities they regulate and use their discretion to make regulations flexible, to the benefit of those regulated entities.</li> <li>3) <u>Implementation</u>: Regulated firms necessarily develop new and efficient technology to replace regulated methods, thus reducing their actual costs below ex-ante predictions (as seen in the case of the Montreal Protocol). These new technologies also improve firm efficiency and therefore save costs. Also, firms may benefit from government incentives to comply.</li> <li>4) <u>Monitoring and enforcement</u>: (ex-post evaluation) , very little ex-post monitoring is done (especially by the firms themselves) and what is done does not reflect total costs or benefits of implementation. The ex post costs of compliance for the firm will be captured in its accounts and may not be separable from other business costs. Calculating the cost of compliance is complicated by the fact that an activity may simply be incorporated into its day-to-day activities. Identifying the specific cost would thus require the construction of counterfactual scenarios.</li> </ol> <p>Regulators must therefore "mind the gap" between actual ex-post costs and ex-ante costs calculated by industries and often used by regulation creators who lack specific information. This gap results from the following generalised situations:</p> <ol style="list-style-type: none"> <li>1) Firms have the incentive to inflate costs of compliance before the legislation is passed</li> </ol>

	<p>2) The same firms will usually work to lower compliance cost after the legislation is passed</p> <p>3) This gap is also due to the fact that firms typically know more about their business activities, economic sectors and associated costs than the regulator does.</p> <p>Bailey et al. also note that while improved compliance cost assessments may be useful in closing the current gap between ex-ante and ex-post compliance, it will not be possible to totally close the gap. What is required is a better understanding of the motivations and bargaining positions of industrial representatives and the factors that tend to lower the realised costs of compliance. There is also a discrepancy regarding the role that ex-ante and ex-post estimates will play in decision making: ex-ante estimates can be useful in the development of environmental regulations without necessarily providing good predictions of ex-post costs. Such ex-ante cost estimates should be seen as an important input in the decision-making process and not as an output intended to be judged on its own merits.</p>
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Author	Ellerman, A.
Title	Ex Post Evaluation of Tradable Permits: The U.S. SO <sub>2</sub> Cap-and-Trade Program
Year	2003
URL	<a href="http://web.mit.edu/ceepr/www/2003-003.pdf">http://web.mit.edu/ceepr/www/2003-003.pdf</a>
Reference	Massachusetts Institute of Technology
Summary	<p>The U.S. SO<sub>2</sub> cap-and-trade program was established as a result of the enactment of the 1990 Clean Air Act Amendments (1990 CAAA) under the authority granted by Title IV, which included several measures to reduce precursor emissions of acid deposition. The SO<sub>2</sub> component consisted of a two-phase, cap-and-trade program for reducing SO<sub>2</sub> emissions from fossil-fuel burning power plants in the United States. The two phases can be discerned as follows:</p> <ol style="list-style-type: none"> <li>1) <u>Phase I</u>: applied only to electric generating units with a generating capacity of more than 100MW. They had to reduce their emissions. Allowances (free of charge for 30 years) were allocated to firms that emitted SO<sub>2</sub> in proportion to the average of each firms' 1985-87 SO<sub>2</sub> emissions. These could be sold to other firms, "banked" by the firm until the next year, or turned in to the EPA after the specified tonnage of SO<sub>2</sub> was released. Firms not affected until Phase II could voluntarily opt-in to phase I.</li> <li>2) <u>Phase II</u>: applied to electric generating units with a generating capacity of more than 25 MW</li> </ol> <p><u>Regulatory scheme:</u></p> <ol style="list-style-type: none"> <li>1) Command-and-control regulations supplement the cap-and-trade program.</li> <li>2) The policy targeted Mid Western firms (which caused acid rain in New England), but in effect treated all SO<sub>2</sub>-producing firms the same (regardless of their location).</li> </ol>
Methodology	<p>Ellerman looks at two counterfactual situations</p> <ol style="list-style-type: none"> <li>1) the ex-ante-ex-post comparison of the entire cap-and-trade system</li> <li>2) the existing SO<sub>2</sub> cap-and-trade permit system, which allows the trading of permits, compared to a counterfactual system that does not allow trading</li> </ol> <p>Economic efficiency is not calculated as a comparison with non-trading systems but as compared to the potential for efficiency within this permit-trading system. Environmental efficiency is measured in terms of the reduction of both SO<sub>2</sub> emissions and acid rain indicators</p>
Results	<p>The trading system is found to be economically efficient. Initial trading showed a great variance in the purchase price of allowances, but after one year, a uniform market price formed and the market remained uniform despite fluxes from \$65 to \$200. This facilitated inter-industry trading between firms (as opposed to trading within the industry). Furthermore, emissions rates declined steadily despite abrupt changes in regulatory limits because the banking of permits (reserving allowances for later years) allowed firms to postpone compliance.</p> <p>Ellerman gives a comparison of compliance cost between:</p> <ul style="list-style-type: none"> <li>• <u>Two ex-post studies</u>, each comparing the current system (with trading) to a counterfactual system without trading: The 2 studies agree on the cost of compliance during the early years of the program (one study estimated compliance costs at \$726 million in 1995 and \$750 m. in 1996, the other study estimated \$832 m. in 1995 and \$910 in 1996). The reason for the discrepancy is that the two tests differ in their computation of the variable costs for SO<sub>2</sub> scrubbers.</li> <li>• <u>Ex-ante and ex-post</u>: The total annual costs associated with early proposals to control acid rain precursor emissions were estimated at \$3.5 to \$7.5 billion. For the proposal that was ultimately proposed and enacted, ex-ante cost estimates for the programme with trading fell to a range from \$2.3 billion to \$6.0 billion. The current estimates for compliance costs in 2010, based on ex-post figures, are significantly lower still, at \$1.0 billion to \$1.4 billion.</li> </ul>

	<p>Most of the disparity results from:</p> <ul style="list-style-type: none"><li>• more stringent regulations anticipated in ex-ante models (initial allowance trading prices of 2 to 10 times the actual rate),</li><li>• different regulatory instruments and different assumptions: early proposals mandated scrubbers at many units and allowed little emissions trading</li><li>• varying assumptions about the response taken by industries, e.g. about the extent to which emissions trading would be used</li><li>• the unanticipated change in the demand for electricity,</li><li>• the relative availability and falling price of low sulphur coal,</li><li>• the availability of improved sulphur reduction technology</li></ul> <p>In terms of environmental effectiveness, the cap-and-trade system is more environmentally effective than was anticipated. It prevented the emission of 33.7 million tons of SO<sub>2</sub> between 1995 and 2001 - 129% of the anticipated 26.1 million ton reduction. Acid rain indicators are also decreasing. Compared to command and control systems, the environmental results of the trading program are as good as if not superior to command and control systems. There is near 100% compliance (and so fewer enforcement costs) because, unlike a single standard, the permit system is flexible and adaptable to unique firm conditions. The administrative / monitoring costs are also much lower in a market-based regulatory system. The fear that regional "hot spots" of pollution will simply buy more permits from areas with fewer point sources is unfounded since the larger firms have more capital to invest in abatement technology.</p>
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Author	Ecotec, in association with GHK
Title	A Study to Evaluate Cost Estimates of Specific Measures Associated with the National Air Quality Strategy
Year	2002
URL	n.a.
Reference	A Final Report to DEFRA, C1966, April 2002
Summary	This study aims to support the development of a better (more accurate) <i>ex-ante</i> compliance cost assessment (CCA) methodology. A detailed <i>ex-post</i> assessment is carried out of a selected policy measure: the UK's regulation enacting Directive 98/70/EC on the quality of petrol and diesel fuels.
Methodology	<i>Ex ante</i> cost estimates are taken from the DETR regulatory impact assessment. Information on <i>ex post</i> costs is mainly based on interviews with senior oil company executives in the UK.
Results	<p>Direct comparison between <i>ex ante</i> and <i>ex post</i> costs has not been possible. Rather the focus of the work has been on identifying the factors that influence estimates of costs. Main findings include the following:</p> <ul style="list-style-type: none"> <li>• There have been a variety of responses adopted by UK refineries to the changes in fuel quality specification. Short-term responses (e.g. importing low-sulphur fuels; blending) required low capital costs, but the capital costs of longer-term strategies (involving designing and building new refinery equipment) will (according to firms) be in line with original estimates.</li> <li>• All companies reported that their initial cost estimates (for technical changes to produce the higher quality fuel specifications) are conservative (on the high side). They felt that the risks of under costing a project were too high for this to be otherwise. Initial estimates were reported as generally being within a +/- 30-40% accuracy.</li> <li>• The oil companies expect technical improvements to occur during the detailed design period of a project, but they do not assume that these improvements will reduce costs as this is too risky. The very high level of capital involved makes the refiners generally wary of relying on unproven technology, so they will favor designs which have been proven elsewhere in the world.</li> <li>• The extent to which firms are involved in defining the detail of the regulation and their ability to make early decisions to allow for the introduction of the regulation has a major impact on compliance costs.</li> <li>• The key variable affecting overall cost level is the required compliance deadline, because of the lead times it allows.</li> <li>• Even in apparently less heterogenous sectors the range of technical responses and hence compliance costs can be significant.</li> </ul>

Author	Hahn, R.
Title	The Impact of Economics on Environmental Policy
Year	1999
URL	<a href="http://www.aei-brookings.org/admin/authorpdfs/page.php?id=85">http://www.aei-brookings.org/admin/authorpdfs/page.php?id=85</a>
Reference	AEI-Brookings Joint Center for Regulatory Studies, Working Paper 99-4
Summary	The paper presents a broad overview of the effect of economic models on policy development. Inter alia, it also discusses the use of ex-ante and ex-post estimates to assess the compliance cost of environmental regulations. Hahn notes that there are three general categories of compliance cost estimates, and respectively of methods to estimate cost savings for incentive-based mechanisms. The first are ex-ante estimates that generally rely on simulations that assume the least cost abatement pattern is achieved. The second are ex-post estimates that rely on market simulations similar to the ex-ante estimates. The third are ex-post savings estimates that use actual data from trades. Hahn concludes that although there are a number of ex-ante simulation studies of potential cost savings from achieving the least-cost pollution abatement scheme for various pollutants, there are relatively few ex-post assessments of actual incentive-based programs and even fewer ex-post assessments of actual cost savings.
Methodology	The effectiveness of incentive-based mechanisms is measured either ex-ante (by models) or ex-post (by either models or actual data). Hahn uses the US SO <sub>2</sub> permit trading scheme as a case study.
Results	Table 3 (p. 35) shows ex-ante and/or ex-post estimates of cost savings for five tradable permit programs for air pollution control; however, of the examples presented, only the SO <sub>2</sub> trading scheme has been investigated both ex-ante and ex-post. In the cap-and-trade program for the regulation of SO <sub>2</sub> emissions, ex-ante costs were grossly overestimated because models failed to take into account new technology, the allocation of 3.5 million bonus allowances, the actual (much lower) set price of the allowances, and the falling price of low sulphur coal.  In sum, Hahn concludes that economic efficiency is often not a high priority in policy design thus far, but environmental economists should encourage policymakers to use benefit-cost analyses when designing policies.

Author	Hammitt, J.K.
Title	Are The Costs of Proposed Environmental Regulations Overestimated? Evidence from the CFC Phaseout
Year	2000
Reference	Environmental and Resource Economics 16(3), p. 281-301
Summary	Hammitt analyses the accuracy of benefit-cost analysis in policy creation. Using the US CFC phase out (under the Montreal Protocol) as a case study, Hammitt compares ex-ante estimates of the marginal cost of limiting chlorofluorocarbon (CFC) consumption in the United States with ex-post estimates based on realised market prices. Estimates published before international regulations were adopted are found to substantially overestimate the marginal costs of limiting CFC-11 and CFC-12 consumption but modestly underestimate the costs of limiting CFC-113 consumption. In contrast, estimates published shortly after adoption of the Protocol appear to underestimate the marginal cost of limiting CFC consumption.
Methodology	<p>There were three ex-ante analyses of the cost of CFC reduction:</p> <ol style="list-style-type: none"> <li>1) <u>RAND</u>: 1986, industry experts under contract to the EPA created a long-run demand curve using currently available technology.</li> <li>2) <u>EPA 1987</u>: unlike RAND, both this and the 1988 were calculated based on models that factored in technology adaptation</li> <li>3) <u>EPA 1988</u>: The only major difference with the 1987 one was that control costs were estimated to be 3 times greater here</li> </ol> <p>Ex-post was compared to ex-ante CFC emissions on a percentage basis from the baseline consumption in 1986, when regulation began. So the reduction is calculated from the projected (ex-ante) amount of CFCs that presumably would have been released but for the regulations.</p> <p>Researchers compared ex-post CFC emission rates to rate projected from pre-protocol consumption. These projected counterfactuals were calculated as three possible “business as usual” baselines.</p>
Results	<p>Ex-ante costs of environmental regulations are systematically overestimated in advance for these reasons:</p> <ol style="list-style-type: none"> <li>1) <u>Asymmetry of information</u>: regulated firms know more about the costs and alternatives than the regulating bodies. They might purposefully exaggerate expected expenditures or only calculate expense for the most-expensive options (during the policy phase) although they will seek the least expensive options during the implementation phase.</li> <li>2) <u>Statutory vagueness</u>: regulatory agencies often interpret vague standards to mean requiring only technology that is currently available, rather than foreseeable and better options.</li> <li>3) <u>Unanticipated technological innovation</u>: firms find ways to reduce costs once the policy is inevitable.</li> </ol> <p>The RAND ex-ante model (which only considered currently available technology) greatly overestimated the costs of reducing 2 CFC compounds but only marginally underestimated the costs of reducing a third. EPA cost estimates (which included technology improvements as a factor) wildly overestimated the initial costs for CFC reductions but were accurate for the costs of mid-term reductions, diverging again in the long term.</p> <p>Per type of CFC, estimates published before international regulations were adopted (in May 1986) substantially overestimate the marginal costs of limiting CFC-11 and CFC-12 consumption but modestly underestimate the costs of limiting CFC-113 consumption. In contrast, estimates published shortly after adoption of the Protocol (in August 1988) appear to underestimate the marginal cost of limiting CFC consumption.</p>

Author	Harrington, W., McConnell, V., Ando, A.
Title	The Enhanced I/M Program in Arizona: Costs, Effectiveness, and a Comparison with Pre-Regulatory Estimates
Year	1999
Reference	Resources for the Future (client US EPA)
URL	<a href="http://www.rff.org/Documents/RFF-DP-99-37.pdf">http://www.rff.org/Documents/RFF-DP-99-37.pdf</a>
Summary	In 1992 the US Environmental Protection Agency (EPA) began testing motor vehicles for compliance with the Clean Air Act Amendments of 1990. Arizona was one of the first states in which testing for HC, CO and NO <sub>x</sub> emissions in grams per mile became mandatory. This study estimates the cost of the Arizona Enhanced Inspection and Maintenance (I/M) Program and the emission reductions achieved. The components of I/M costs are identified. This is followed by a description of the empirical information from Arizona and the methodology used to construct cost estimates for both vehicle inspection and repair of failing vehicles. Inspection costs include the costs of operating the test stations and the costs motorists incur in time and money to get to the station and go through the testing process.
Methodology	<p><u>Cost types</u></p> <ol style="list-style-type: none"> <li>1) <u>Non-monetary</u>: time is calculated in terms of average hourly wage after tax (\$8. 62) <ol style="list-style-type: none"> <li>a) Motorists cost travelling to and from the station <ol style="list-style-type: none"> <li>i) Average time for Arizona motorists to reach a station (27 min., so \$3.88 per trip)</li> <li>j) Cost of operating the vehicle (\$.25 per mile, so \$2.25 per trip)</li> </ol> </li> <li>b) Motorist time at the station (27 min.) <ol style="list-style-type: none"> <li>i) Waiting before the test as estimated using the average test duration and average queue lengths (18.3 min.)</li> <li>j) Total “vehicle service time” includes set-up time and is a factor of the duration of the actual test (8.7 min.)</li> </ol> </li> </ol> </li> <li>2) <u>Monetary</u>: <ol style="list-style-type: none"> <li>a) Operation of the test stations reported by the sub-contracting station operators (burden on the tax payers)</li> <li>b) Vehicle repair calculated from repair reports submitted by motorists. Where motorists repaired their own cars or a warranty covered the cost of repair, time and raw materials were imputed (burden on either the motorist or the manufacturer, if there is a warranty)</li> </ol> <p>Only the final cost type (vehicle repair) directly achieves the policy goal of reducing emissions.</p> </li> </ol>
Results	<ul style="list-style-type: none"> <li>• Inspection costs account for over 2/3 and vehicle repair accounts for just 1/3 of actual costs.</li> <li>• EPA’s ex-ante estimates for the total costs are 15% below Arizona’s actual costs. This is mainly because the EPA overestimated improvements in fuel economy. Other ex-ante predictions were similar to the ex-post results despite the following differences. <ul style="list-style-type: none"> <li>• First, although the average costs of repair are higher than the EPA ex-post analysis, the failure rates are lower.</li> <li>• Secondly, the EPA used a higher average wage (\$20 per hour) to calculate the value of waiting time.</li> <li>• Lastly, the EPA reports higher reductions in pollutants (35-39% for HC and CO) than this study discovered (12-13% for HC and CO).</li> </ul> </li> </ul>

Author	Winston Harrington, Richard D. Morgenstern and Peter Nelson
Title	On the Accuracy of Regulatory Cost Estimates
Year	2000
Reference	Journal of Policy Analysis and Management, Vol. 19, No. 2, 297–322 (2000) (also published as Discussion Paper 99-18, Resources for the Future, January 1999)
Summary	<p>This study compares ex-ante estimates of the direct costs of individual regulations to ex-post assessments of the same regulations. For total costs the results support conventional wisdom, namely that the costs of regulations tend to be overestimated. This is true for 14 of the 28 rules in the data set discussed, while for only 3 rules were the ex-ante estimates too low. For unit costs, however, the story is quite different. At least for EPA and OSHA rules, unit cost estimates are often accurate, and even when they are not, overestimation of abatement costs occurs about as often as underestimation.</p> <p>In contrast, for those rules that use economic incentives, unit costs are consistently overestimated. The difference between the total-cost and the unit cost results is caused by frequent errors in estimates of the effects of individual rules, which suggests, in turn, that the rule's benefits may also be overestimated. The quantity errors are driven both by difficulties in determining the baseline and by incomplete compliance. In cases of unit-cost overestimation, unanticipated technological innovation appears to be an important factor—especially for economic incentive rules, although procedural and methodological explanations may also apply.</p>
Methodology	Harrington et al. found that the over- or under-estimation of the costs of environmental regulation are due, inter alia, to the omission of certain types of data and the accuracy of the data in regulatory compliance assessments. In estimating the cost of environmental regulation not all important cost elements are included, for example, those cost categories that are difficult to measure such as diverted management attention. Where compliance costs were lower than predicted this was mainly due to the unanticipated use of new technology. The more flexibility given to a particular industry or firm in meeting an environmental regulation the more difficult it is to anticipate the technical responses and the costs of achieving the regulatory requirements.
Results	Harrington et al. conclude that cost estimations assist regulators in determining the full economic implications of a new regulation and estimated high costs can motivate a search for regulatory options that have lower costs with little or no reduction in benefits. They argue that ex-ante estimates can be useful in the development of environmental regulations without necessarily providing good predictions of ex-post costs. Cost estimates should be seen as inputting into environmental regulatory decision-making and not as an output intended to be judged on its own merits.

Author	Pickman, Heidi A.
Title	The Effect of Environmental Regulation on Environmental Innovation
Year	1998
URL	n.a.
Reference	Business Strategy and the Environment 7 (4), p. 223-233
Summary	Environmental expenditure estimates resulting from US environmental policy are based on current technology which may overstate policy's true costs. Existing evidence shows that <i>ex ante</i> cost estimates are greater than realized costs due to unexpected technological progress. The article provides evidence that innovation is a response to environmental regulation.
Methodology	The author conducts an empirical study of the US manufacturing industry's environmental patent activities and environmental regulation as measured by pollution abatement and control expenditure (PACE) data. She finds a statistically significant positive relationship between environmental regulation and innovation when estimated by ordinary least squares (OLS). However, the OLS coefficient of pollution abatement costs is inconsistent because of a correlation between the explanatory variable and unobservable variables. Two-staged least squares addresses the inconsistency problem, resulting in positive and significant PACE coefficients.
Results	It is concluded that environmental regulation causes industry to innovate in an environmental direction, but diverts resources from other types of innovation, without however causing a decline in total innovation. Thus, there is a substitution of innovation efforts. From a policy standpoint if environmental regulation can influence the direction of innovation without causing a decrease in overall innovation and the environmental protection is a policy priority, then in the aggregate true regulatory cost burden is overstated unless technological progress is considered in <i>ex ante</i> regulatory cost estimates.

Author	Stockholm Environment Institute
Title	Costs and Strategies presented by Industry during the Negotiations of Environmental Regulations
Year	1999
Reference	SEI, Stockholm
Summary	Based on five case studies, this study compares the cost-avoiding strategies employed by industries threatened with environmental regulations. During the negotiation of international and European environmental regulations, the industry sector typically raises the issue of the cost of compliance. It is often maintained that the cost of complying with environmental regulations restricts business profitability and competitiveness. This paper provides an overview of the cost of compliance by considering the arguments, strategies and cost estimates that were presented by industry during the negotiations of several different environmental regulations in Europe and North America, and at the global level. It examines the difficulties associated with comparing costs using pre- and post-regulation cost data and discusses the strategies adopted during the negotiations of the regulation and once the regulation was implemented. The paper concludes that although some proposals for regulation may impose burdens on industry, which it will oppose, industry has come to recognise that environmental regulation does not necessarily mean increased costs at the level anticipated. While regulation cannot guarantee innovation or lead to greater competitiveness and higher productivity for all firms, those that seize the opportunities will usually gain benefits. The paper reinforces the view that the EU should give careful consideration to the costs presented by industry as in the past it has tended to overestimate costs of compliance and underestimate the potential for the development of new technology. The introduction of independent cost assessments and technology assessments may be one way of overcoming this problem.
Methodology	The study notes that different conceptions of “costs” are invoked by different actors. Industry defines costs as strictly economic burdens (prices, jobs and profits) that decrease their profits. By contrast, policy-makers balance costs to industries with decreased costs for the public and the environment (“benefits”) to find the “total cost” of the policy (i.e. based on a concept of social costs).
Results	Results are presented for five selected case studies of regulatory instruments: <ol style="list-style-type: none"> <li>1) <u>UN/ECE protocol on acidification and EC LCP directive</u> – ex-ante costs anticipated by industries were much greater than the costs anticipated by regulators; actual (ex-post) costs appear substantially lower than industry estimates.</li> <li>2) <u>EC directive on vehicle emissions / catalytic converters</u> - The car manufacturers were forced at first to absorb costs rather than pass them on to consumers, but costs reduced with time (especially since car manufacturing is a high-volume industry with associated economies of scale).</li> <li>3) <u>European Auto-Oil Programme</u>: When the affected industries (motor industry and oil industry) were forced to negotiate a regulatory scheme, they took sides against each other, questioning each others’ estimates and actually increasing environmental protection.</li> <li>4) <u>US Clean Air Act</u>: as with the other case studies, the industries’ cost estimates are general, rather than specific. Notwithstanding methodological difficulties, ex-post evaluation of the Act undertaken by the Environmental Protection Agency shows much lower compliance costs for industry than predicted by industry figures (\$51 to US \$91 billion per year ex ante as opposed to US \$22 billion ex-post (1996). Neither did the dramatic damaging effect on employment occur as predicted – in fact new jobs were created.</li> <li>5) <u>Montreal Protocol</u>: The industry clearly exaggerated compliance cost and inconvenience when compared to the actual ex-post cost and implementation experience, as is often the case in an industry with a strong potential for innovation. The case demonstrates that substitutes can often be found that not only reduce compliance costs, but may even be</li> </ol>

	<p>beneficial to industry itself.</p> <p>The cost of regulations is also compared for different regulatory instruments:</p> <ol style="list-style-type: none"> <li>1) <u>Voluntary regulations</u> (of the UK) are generally as effective as command-and-control techniques (more common in the US), in part because they do not generate hostility between government and business and they are less costly to monitor and enforce.</li> <li>2) <u>Taxes</u> on the polluting activities are the next least intrusive and bureaucratically expensive regulatory mechanisms, but taxes are difficult to adjust according to changing technology or need.</li> <li>3) <u>Tradeable permits</u> (more appropriate for industries than individuals) is a more cost-effective method of regulation. The innovation that permits encourage provides industry with the secondary benefits of general technological innovation and the competitive advantage of marketing a “green” product.</li> <li>4) <u>Command and control</u></li> </ol> <p>The report lists different reasons for differences in cost estimates:</p> <ol style="list-style-type: none"> <li>1) cost analyses differ in which cost categories they consider and which methods they use to calculate cost.</li> <li>2) Firms have various methods for dealing with increased costs and tend to be creative in problem-solving in order to remain solvent.</li> <li>3) External costs (which are minimised by environmental regulations) are often not included</li> </ol> <p>Industries often defend the status quo by asserting that:</p> <ol style="list-style-type: none"> <li>1) The regulation will have no effect on the environmental problem it seeks to remedy</li> <li>2) Jobs will be lost at a cost to the community</li> <li>3) The industry will be put at a competitive disadvantage compared with other countries</li> </ol>
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