A Comparison Of Deregulation, Electrical Efficiency Programs, And Integrated Market Transformation Policies: Impacts On Carbon Emissions And Service Costs In Western Europe's Power Sector

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Synopsis

The study finds that limited reform proposals based solely on restructuring and deregulating the electricity supply industry are associated with large opportunity costs that have been widely overlooked.

Abstract

This paper summarizes an in-depth analysis of the impacts of alternative policy instruments for transforming the electricity sector on the costs of electricity services and on carbon dioxide emissions. Using scenario modeling analysis, the study calculates year 2020 service costs and carbon emissions for a five-country region within the European Union: France, Germany, Italy, the Netherlands, and the United Kingdom.

The following scenarios and policy frameworks are examined: (1) business-as-usual scenarios based on pre-1990 industry structures and planning regimes; (2) a „pure“ deregulation scenario providing access to the electricity market for all suppliers; (3) deregulation combined with market transformation programs for addressing non-entry barriers to cogeneration, renewables, and demand-side energy efficiency technologies; (4) a low-cost, low-carbon scenario based on framework 3.

A decisive input for these scenarios is an in-depth assessment of the cost and economic potential of electrical efficiency improvements in Western Europe. Additional analyses examine the sensitivity of results to alternative fuel price forecasts. The study also draws on in-depth analysis of possible technology improvements and cost developments in electricity generation to capture uncertainties in the highly dynamic competition between alternative resource options. Special attention is paid to the relative costs of electricity savings and electricity production as feedback effects of policy measures bring about declines in both pre-tax fuel prices, generating costs, and in the costs of energy efficiency improvements. The impact of incorporating environmental externalities is also quantified. All results are expressed as a function of the degree to which policies succeed in mobilizing cost-effective resource potentials.

The study finds that limited reform proposals based solely on restructuring and deregulating the electricity supply industry are associated with large opportunity costs that have been widely overlooked. The economic benefits of pure deregulation are found to be significantly smaller than those of an integrated least-cost or minimum-carbon policy reform. The study further indicates that under pure deregulation, power sector carbon emissions are likely to rise significantly in the longer-run, while aggressive implementation of efficiency potentials could lead to significant absolute emission reductions below present levels. Due to various feedback effects between policies and the costs of energy efficiency and other resources, even a minimum carbon strategy is found to result in significantly larger economic benefits than deregulation alone.

1. Introduction

With the global warming threat looming ever larger, power sector reforms and environmental policy are heading for a clash. While the world's governments are negotiating legally binding reduction targets for fossil carbon dioxide and other greenhouse gas emissions with one hand, many of the same governments pursue with their other hand a course of economic deregulation that will increase utility sector carbon emissions.
The headlong rush into utility industry restructuring despite these disconcerting environmental implications is usually justified by the economic benefits such reform may bring. Support for it is particularly strong among large industrial utility customers who expect to obtain lower electricity rates in a deregulated electricity system. By contrast, some macroeconomic analysts have linked reductions in greenhouse gas emissions with slower economic growth.

The present paper challenges these perceptions of a seeming trade-off between lower electricity bills and lower emissions and argues that no such contradiction does in fact exist: Excitement over the potential benefits of competitive restructuring of the electricity supply industry has distracted attention from another economic prize that is as large or significantly larger in size, more equally beneficial for all energy users and moreover, an elegant means for harmonizing money-saving utility reforms with emerging global environmental imperatives.
This economic prize is found in the enormous potential for using electricity more efficiently, both in a technical and in an economic sense. Fifteen years of experimentation with policies and programs to increase the efficiency of electricity use, and the many market research and program evaluation studies accompanying such programs, have shown that

- The appliances, lights, motors, electronics, and other end-use technologies used by consumers and firms in industrialized countries suffer from technical inefficiencies that create much higher life cycle costs than economically optimal technologies would have.
- These unrealized opportunities to cost-effectively improve energy efficiency exist because the markets for energy efficiency suffer from high transaction costs, asymmetric information, and other pervasive problems. These problems are mainly market failures in the classical economic sense (Sanstad and Howarth 1994, Koomey and Sanstad 1994).
- Most of these market failures can be cost-effectively reduced or eliminated through government action to transform the market arrangements under which electricity supplies compete with investments in more efficient end-use technologies (IPSEP 1993, Krause 1995).

One such market transformation (MT) tool is the set of voluntary or legally mandated energy efficiency standards for electricity-consuming appliances, building shells and equipment. Energy efficiency standards are already generating large economic benefits for consumers in the U.S. (USDOE 1993, Greening et al. 1996, Koomey et al. 1995, McMahon et al. 1990). Various standards are now in the process of being adopted in Western Europe and other countries (GEA 1993).

An equally important, complementary market transformation approach is found in utility-sponsored demand-side management and technology procurement programs. Utility demand-side programs have been successfully implemented by hundreds of utilities and many state and local governments in North America (Nadel 1990) and increasingly also in Western Europe (Mills 1993, UNIPEDE 1994) and elsewhere (Vine 1995). Barring some early exceptions, these programs have proven robustly cost-effective.[1]

Lack of a systematic expansion and sustained application of such policies, both in the U.S. and even more so in Western Europe and other OECD countries, has led to a large backlog of unrealized money-saving energy efficiency investments: Over a period of 20-30 years, and with full application of available technologies, specific electricity requirements across all applications could be cut by 40-60 percent relative to current average stocks (IPSEP 1996). On a levelized cost basis, at least two thirds of of these demand-side resources are cost-effective against new capacity fired by cheap natural gas (IPSEP 1996). Because these so-called negawatt resources eliminate the need for substantial generating capacity, they represent a major opportunity for reducing carbon emissions at negative net cost to the economy, i.e., at a net benefit for consumers and firms (Krause et al. 1992).
Given this context, the following specific questions are of particular importance for policy makers:

— What are the emission impacts of narrow utility sector deregulation reforms aimed purely at introducing competitive generation and retail markets?
— What are the emission impacts of more comprehensive reforms that include policies to implement cost-effective demand-side efficiency improvements and other „no-regrets" potentials?
— How do the economic benefits of pure deregulation compare with the economic benefits of an integrated transformation of both electricity supply markets and energy efficiency markets?
— How much could emissions be reduced if the goal of minimum cost were subordinated to the goal of maximum emission reductions?
— How would these results change if environmental goals were extended to include minimization of threats associated with nuclear power?
— What is the difference in economic outcomes between a business-as-usual scenario, a least-cost strategy, and a minimum emission or minimum risk strategy?

2. Methodology and scope

The above questions were analyzed in several recent reports (IPSEP 1994/1995/1996) for a group of five industrialized countries: France, Germany, Italy, Netherlands, and the UK. The study of these European countries is of broader significance for OECD countries as a whole. As a group, Western European economies are already less energy- and carbon-intensive and more energy-efficient than the U.S. One dynamic that has helped reduce the carbon intensity of Western European electricity production in the past, i.e., the expansion of nuclear power, is unlikely to persist and may even be reversed. For these reasons, reducing carbon emissions by a given percentage below base year levels could be more costly in Western Europe than in other countries. Also, the status quo energy mix and the carbon intensity of electricity generation vary widely among the five countries, thus providing a representative sample of the range of conditions encountered in most OECD countries and utility systems. Finally, the group of countries studied is statistically significant within the OECD context: it comprises about three quarters of energy use and carbon emissions in the European Union, and a population of 250 million that is comparable to that of the U.S.

2.1 Range of policy scenarios

The study summarized here comprises scenario simulations of twelve different policy frameworks over the 1985-2020 period. In this paper, results for the following scenarios will be reported:[2] (1) business-as-usual scenarios based on pre-1990 utility industry structures and planning regimes; (2) a narrow deregulation scenario providing equal access to the electricity market for all suppliers; (3) an integrated least-cost approach based on framework 2 plus market transformation programs for demand-side energy efficiency technologies; and (4) a low-carbon scenario based on a modification of framework 3.

2.2. Development of input parameters and sensitivity cases

Business-as-usual projections of energy demand and resource mixes, as well as policy-based modeling studies, often fail to incorporate a sufficiently wide sensitivity range for fuel prices and technology cost assumptions. Nor do they sufficiently reflect basic economic feedbacks, such as the price-reducing effects of market transformation policies on energy efficiency and other low-carbon technologies. To avoid these problems, the study summarized here draws on in-depth analyses of possible technology improvements and cost developments to capture uncertainties in the highly dynamic competition between alternative resource options. Special attention is paid to shifts in the relative costs of electricity savings and electricity production as feedback effects of policy measures bring about declines in both pre-tax fuel prices, generating costs, and in the costs of energy efficiency improvements. These feedback effects are quantified in stylized fashion by correlating the use of high and low input assumptions for each fuel and technology with various policy cases.

Ranges for fossil fuel prices are adopted from the study of the European Commission (CEC 1990). In the low case, both coal, oil, and gas prices remain practically flat. In the high case, oil and gas prices rise significantly. The resource potentials of energy efficiency, cogeneration, renewables, and nuclear power are developed in extensive substudies (IPSEP 1994/1995/1996). Cost estimates include consideration of back-up costs, modularity benefits or penalties, and other system-level costs and benefits. In quantifying the resource potentials of energy efficiency for different time horizons, the replacement rate of energy-using capital stocks is taken into account. Renewables potentials reflect strong environmental constraints, as well as the time needed to build sufficient manufacturing capacity. In all cases, a uniform 5 percent real discount rate is applied, i.e., resource potentials and costs are defined from a societal perspective. This perspective is a prerequisite for identifying policies that can produce least-cost outcomes and welfare maximization.

Also addressed in the study are legitimate disagreements among policy makers and analysts as to what level of future policy action and policy effectiveness can be realistically expected in mobilizing unconventional resources such as the negawatt, cogeneration, and renewables-based potentials. To make the results useful for all viewpoints, this issue is addressed by introducing the concept of an achievable fraction. This fraction, which is varied in 25 percent increments from 25 to 100 percent, indicates how much of the potential of each unconventional resource option is being successfully accessed and participates in the least-cost competition. The success of policy implementation thus is an explicit variable in the scenario formulations.
The 100 percent case represents outcomes under an optimally effective policy regime. For the final year of the scenarios (2020), this case applies the entire identified electrical efficiency resource. For prior years, the resource is scaled down on the basis of capital stock growth and turnover rates using average equipment lifetimes. An initial ramp-up phase for policy programs is also allowed for. Though a 100% successful implementation of cost-effective resources may not be achievable in practice, it provides an important economic yardstick. It indicates the opportunity costs of political compromises that lead to lesser policy goals, and thus provides a valuable normative basis for improving the decision-making process.

2.3. Modeling procedure

The modeling framework for integrating competing resources is described elsewhere (Krause et al. 1992). Emphasis is placed on the longer-run effects of alternative policies, as measured by the resource mix and electricity service costs for the final year of the scenario period. One and the same level of energy service demand is used in all policy cases, a procedure that tends to underestimate the economic benefits of policy cases that lower energy service costs while only slightly overestimating demand and emission reductions (Krause 1996). Retirements of existing plants are generally based on the business-as-usual projections of the European Commission, but modified by more stringent environmental standards and nuclear safety requirements and/or, as the case may be, by economically attractive reductions in electricity demand.

3. Business as usual (BAU) scenario

The business-as-usual scenario extrapolates the electricity projections of the Directorate of Energy (DG XVII) of the European Commission (CEC 1990). This scenario is characterized by a 2.1-fold increase in (energy-weighted) electricity services and a roughly 1.8-fold increase in electricity demand, reflecting significant further electrification of energy use and modest improvements in electrical end-use efficiency. It also includes a significant expansion of nuclear power (notably in France). As a result, power sector carbon emissions increase by only about 20 percent over the scenario period (Table 3.1).

Table 3.1: Year 2020 Carbon Emissions and Electricity Service Costs, EU-5 Power Sector: Results for Key Policy Cases and Sensitivity Tests

		Scenario cases			Low fuel prices, low technology costs				Low fuel prices, high technology costs			
		Resource availability Renewables/ cogeneration	Resource availability Demand-side efficiency	Code	Total cost of electricity services billion ECU	index	C emissions Power sector million tC	index	Total cost of electricity services billion ECU	index	C emissions Power sector million tC	index
0)	1985 base year	n.a.	n.a.		n.a.		180	*1,00*	n.a.		180	*1,00*
1)	Business as usual	-	0%	BAU	153	*1,00*	216	*1,20*	165	*1,00*	220	*1,22*
Incomplete market transformation												
2)	Narrow deregulation	25%	0%	DR	143	*0,93*	309	*1,71*	145	*0,88*	333	*1,84*
3a)	Dereg./ Supply-side Market Transformation	50%	0%	DR&SSMT 50%	141	*0,92*	279	*1,55*	144	*0,87*	318	*1,76*
4a)	Integrated Market Transformation	50%	50%	DR&IMT 50%	113	*0,74*	166	*0,92*	129	*0,78*	229	*1,27*
	Low environmental risk/least cost	50%	50%	LOWR/LC 50%				*0,00*		*0,00*		*0,00*
5a)	Minimum environmental risk	50%	50%	MINR 50%	0	*0,00*	0	*0,00*	136	*0,82*	139	*0,77*
	Low carbon/least cost	50%	50%	LOWC/LC 50%	117	*0,76*	81	*0,45*	139	*0,84*	98	*0,54*
6a)	Minimum carbon	50%	50%	MINC 50%	124	*0,81*	40	*0,22*	153	*0,93*	40	*0,22*
Optimal market transformation												
3b)	Dereg./ Supply-side Market Transformation	100%	0%	DR&SSMT 100%	138	*0,90*	222	*1,23*	142	*0,86*	292	*1,62*
4b)	Integrated Market Transformation	100%	100%	DR&IMT 100%	87	*0,56*	74	*0,41*	117	*0,71*	162	*0,90*
	Low environmental risk/least cost	100%	100%	LOWR/LC 100%								*0,00*
5b)	Minimum environmental risk	100%	100%	MINR 100%	0	*0,00*	0	*0,00*	124	*0,75*	30	*0,17*
	Low carbon/least cost	100%	100%	LOWC/LC 100%	87	*0,56*	56	*0,31*	117	*0,71*	107	*0,59*
6b)	Minimum carbon	100%	100%	MINC 100%	87	*0,57*	21	*0,12*	125	*0,76*	21	*0,12*

Fuel price projections based on CEC (1990) and IPSEP (1995a).

Technology cost ranges for efficiency, nuclear, and renewables based on IPSEP (1994, 1995b, 1996).

All policy cases are based on the same level of energy services (see CEC 1990 and IPSEP 1996).

4. Policy scenarios: results

The key scenario results are summarized in Table 3.1. Of the wide range of combinations of input assumptions analyzed in the study, we present only the variants involving low fuel prices (LF): low (pre-tax) fossil fuel prices are the most plausible projection in the context of aggressive efforts to curtail carbon emissions.[3]

Also, the low/high variations of technology costs in the sensitivity cases listed in Table 3.1 capture only some of the likely impact of aggressive climate protection policies on the costs of key low-carbon technologies. In the pessimistic (HT) case, these feedbacks are ignored, and technology cost and performance improves little. In the LT case, both energy efficiency, renewables, and nuclear costs evolve in line with more optimistic expectations that are plausible if major R&D and commercialization policies were simultaneously pursued for each.[4]

For purposes of illustration, Table 3.1 shows cases based on either a 50 percent or a 100 percent realization of energy efficiency, cogeneration, and renewable resource potentials. The 100 percent case provides a normative economic efficiency viewpoint. The 50 percent case illustrates a more limited degree of policy implementation taking into account prevailing factors of political economy.

4.1 Narrow deregulation

Assuming that deregulation reforms do succeed in establishing a well-functioning competitive power generation market, the longer-term prices of electricity services would decline by 7-12 percent relative to the business-as-usual case. This result is consistent with other estimates on how competitive restructuring would lower longer-run electricity prices (CEC 1989).[5]

However, the longer-term impact of a narrow deregulation approach on power sector carbon emissions turn out to be quite negative: Year 2020 emissions increase by about 70 to more than 80 percent relative to base year levels, compared to only about 20 percent in the business-as-usual case.

A number of factors explain this deterioration on the emissions side. First, low fuel prices make power from new reactors more expensive than from new fossil-generated baseload power. Though gas-fired new capacity makes strong gains relative to the coal-intensive business-as-usual case, the corresponding reductions in carbon emissions are overcompensated by the displacement of retired nuclear capacity with cheaper fossil-fired capacity. Second, a significant number of nuclear plants end up being stranded investments, partly because of high operating costs, partly because stronger safety constraints limit nuclear life extensions. At the same time, a portion of existing coal plants benefit from an extended economic life on account of retrofits that were part of recent efforts to limit classical air pollution. Third, renewables and reactors are at a disadvantage on account of their high capital requirements and attendant financial risks, even when nominally cost-competitive on a levelized basis. Fourth, renewable energy sources and low-carbon industrial cogeneration and municipal combined heat and power projects continue to face significant market barriers other than market access. Finally, deregulation fails to mobilize cost-effective demand-side resources beyond those already implemented in the business-as-usual case. Though these problems could be addressed through supplementary policies, the pure deregulation case excludes such measures by definition.

4.2 Deregulation plus integrated market transformation

The integrated market transformation strategy assumed in this case (i.e., introduction of competition in electricity supply markets plus a series of market transformation programs aimed at removal of other institutional and market barriers impeding take-up of societally cost-effective resources, notably cogeneration and energy efficiency; see also Krause et al. elsewhere in these Proceedings) represents a true least-cost strategy from an economic point of view, since it mobilizes all resources on the basis of their technology system cost in a manner consistent with perfect market structures. Relative to business as usual, consumers and firms in the EU-5 region would save 36-66 billion ECU per year in 2020 (Table 3.1). Thus, the net economic benefit of an IMT policy framework is 2-5 times larger than that of pure deregulation. By neglecting the larger benefits of energy efficiency in pursuit of the smaller benefit of competitive restructuring, narrow deregulation reforms end up burdening consumers and firms with an opportunity cost of 16-56 billion ECU. Environmental externalities and the relatively higher fossil fuel prices accompanying the narrow deregulation framework have been neglected in the figures shown in Table 3.1, and would thus add to this opportunity cost.

An IMT strategy is not only far superior economically; it also is of decisive importance for climate stabilization, which requires major reductions in carbon emissions below present levels. As shown in Table 3.1, neither narrow deregulation reforms (case 2) nor the establishment of fully efficient markets for low-carbon cogeneration and renewables (cases 3a and 3b) are sufficient to reach this goal. The only scenario cases succeeding in emission reductions below base year levels are those incorporating major portions of the demand-side efficiency resources that remain unrealized in the business-as-usual case.

At the same time, absolute emission reductions are quite unpredictable under this strictly economically oriented policy framework. If one assumes only moderately aggressive policy programs (50% successful in mobilizing negawatt resources), emission reductions below base year levels remain small at best — of the order of 10 percent. Only with full program success including strong policy feedbacks would major cuts be realized. Given the wide, -59 percent to +27 percent range of emission outcomes shown for the integrated market transformation (IMT) case (Table 3.1), it is clear that a narrowly economic approach to utility sector reform will not reliably succeed in meeting global environmental challenges, even when the policy approach is properly balanced and comprehensive. However, the large economic savings realized by the IMT approach relative to both the business-as-usual case and the narrow deregulation reform provide policy makers with greatly enlarged degrees of economic freedom in pursuing environmental goals, as illustrated by the following case.

4.3. Low carbon emissions/least cost

This case modifies the IMT framework by making low carbon emissions as important a policy goal as low economic costs. Low carbon resources are selected on the basis of increasing marginal cost per unit of carbon reduction. The point of reference for calculating these marginal costs are the per-kWh generating costs and carbon burdens of existing coal plants.

Table 3.1 shows that this policy change results in assured absolute emission reductions below the base year that are both significantly larger and more predictable than in the purely least-cost oriented IMT policy case. Already with incomplete implementation, emission reductions reach 46-55 percent below the base year (50% implementation) and as much as 69 percent with optimal policy implementation (100% case).

Equally significant, and perhaps more surprising, these substantial improvements in emission abatement come at a moderate or negligible extra cost relative to a purely economic optimization (IMT only). As before, costs are higher under incomplete implementation (50% case), because a major portion of the money-saving energy efficiency and low-carbon cogeneration resources remain blocked. Instead, more expensive renewable and nuclear resources enter the mix. Nevertheless, total electricity service costs remain at or well below those for the deregulation case, which took emissions strongly in the opposite direction.

Under optimal policy implementation, costs are substantially lower still, and become virtually identical with those of the least cost IMT case. Here, the remaining money-saving energy efficiency are fully realized. Because of the reduced demand, low-carbon gas-fired cogeneration and the cheaper renewables now make a sufficient contribution to displace nuclear power and the more expensive renewables.

5. Conclusions

Narrowly conceived, supply-oriented competitive restructuring reforms, as now being pursued in Western Europe and other countries, will fail to provide much of the economic relief electricity consumers could enjoy with broader policies, and may substantially worsen the threat of global warming. Though a well-designed and successfully implemented competitive restructuring reform does offer clear economic benefits, significantly larger gains could be realized by combining such reforms with integrated market transformation (IMT) policies for energy efficiency, cogeneration, and renewables.

The potential savings of such an IMT approach relative to narrow deregulation proposals are easily large enough to insulate consumers and firms from any extra costs associated with strong restraints on utility sector carbon emissions. Integrated policies that reduce Western Europe's power sector carbon emissions by about 40-70 percent below base year levels could produce far larger economic benefits than narrow competitive restructuring reforms alone, which exacerbate growth in carbon emissions.

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Endnotes

[1] Suggestions to the contrary by Joskow and Marron (1993) were based on narrow empirical samples and incomplete data, and have been disproven as more complete empirical data became available (Eto et al. 1994, 1995, USDOE 1995). Theoretical economic critiques of the cost/benefit tests used for demand-side management programs have been found to be flawed and tautological (Levine and Sonnenblick 1994, Sanstad and Howarth 1994).

[2] To simplify discussions, the cases summarized in this paper do not include energy or carbon taxes, though such taxes could be an attractive and important complement to the various market transformation policies and the cross-cutting emission caps implied in the least carbon scenario (Howarth and Anderson 1993, Krause 1995). Inclusion of taxes creates additional complexities by obscuring the degree to which energy efficiency and low-carbon supply resources are cost-effective without imposition of energy taxes favoring them, and by introducing a cost component whose net effects on economic growth could be either positive or negative, depending on the assumed tax recycling scheme. By contrast, the above scenarios capture the impact of each policy framework in such a way as to make at least the sign of macroeconomic impacts predictable: higher costs of electricity services mean slower growth, lower costs mean faster growth (Zimmerman 1990).

[3] The use of one and the same low fuel prices in both the business-as-usual case and the alternative policy cases means that most of the feedback effects on fossil fuel prices from changing emission levels are not captured. The results shown in Table 1 will thus tend to overstate the cost of electricity services for the cases involving major carbon reductions below business-as-usual levels, and understate costs for the deregulation cases under which emissions would increase.

[4] Real-world crowding-out effects, and the superior historic performance of energy efficiency and some renewable technologies compared to nuclear technologies, are ignored here. In practice, most governments would find it impossible to simultaneously pursue aggressive R&D and commercialization programs for both nuclear power and energy efficiency and renewables, on account of the disproportionate scale of nuclear technologies and the enormous budget requirements of nuclear programs. Results based on such further differentiations assuming either low costs for energy efficiency and renewables and high costs for nuclear power, or the inverse, will be summarized in a future publication.

[5] Higher percentage savings are sometimes cited in association with proposals to strand existing powerplant investments that would be uneconomic under deregulation. However, it can be argued that such imputed savings during a transition period are not economic efficiency gains uniquely attributable to deregulation, since these plants could and should be subject to economic retirement under efficient cost-plus regulations using the „used and useful“ regulatory test.