Flexibility with no regrets: an energy efficiency based, least cost approach to the Kyoto targets and mechanisms

Florentin Krause, International Project for Sustainable Energy Paths (IPSEP)

1. SYNOPSIS

A least-cost comparison of the Kyoto mechanisms with domestic market and fiscal reforms shows that a more than supplementary role for the Kyoto mechanisms would be economically inefficient.

2. ABSTRACT

This paper examines a global least-cost approach for mitigating climate change. This strategy consists of domestic energy market and fiscal reforms, complemented by international flexibility mechanisms. Economic analysis of such an approach reveals the decisive role of domestic market reform programs to stimulate cost-effective investments in energy efficiency. It also reveals that the economic significance of international allowance trading has been exaggerated.

The potential contribution of profitable domestic 'no regrets' energy efficiency options in realising the Kyoto targets for industrialised countries is quantified on the basis of recent state-of-the-art scenario studies for the EU and the U.S. These studies show that cost-effective domestic energy efficiency options can supply a majority of required carbon reductions in 2010 and can contribute even larger 'no regrets' reductions in 2020 if a number of targeted market reforms are implemented. When carbon charges are implemented, tax restructuring can augment the benefits of energy bill savings, leading to large net gains in economic welfare from domestic action alone. Extrapolation to the Annex II countries with Kyoto commitments yields Annex II benefits of more than $200 billion/year in 2010 and more than $450 billion/year in 2020, equivalent to 1 percent and 1.75 percent of projected GDP.

Measured against benefits obtainable from domestic market and fiscal reforms, the marginal economic benefits from the Kyoto flexibility mechanisms are found to be a roughly 5 percent effect. In an integrated least-cost approach, international JI and CDM projects still have an important role to play, but are limited to a supplementary role for purely economic reasons.

3. INTRODUCTION

The challenge of carbon mitigation is not one of managing and sharing economic pain, but one of mobilising and sharing economic gains. This is the principal message emerging from two new studies on mitigation costs for the U.S. and the EU whose economic implications are synthesised in this paper. One is the 'Clean Energy Futures' study prepared by a team of researchers from several U.S. national laboratories, the other is the 'Energy Policy in the Greenhouse' study by the International Project for Sustainable Energy Paths.

The two studies point to fundamental misperceptions of the costs of carbon mitigation, both in the wealthy OECD countries (Annex II), and in developing countries (non-Annex B). Conventional wisdom has it that abatement of greenhouse gas emissions would unavoidably involve across-the-board economic losses and pain; and that governments need to negotiate a difficult course between the environmental advantage of early and stronger action and the perceived economic advantage of later and weaker action. This perceived conflict between economic and environmental goals has created a quandary for the UN COP negotiations.

The conventional notion of unavoidable losses can be traced to the use of outdated economic models. These rely on assumptions of optimised markets and fixed rates of energy efficiency improvements. They are at odds with modern economic thought, which recognises the role of information and transaction costs, institutional arrangements, and related policy choices in shaping investments in energy efficiency technologies. As such, they are ill suited for simulating innovative productivity-enhancing policies. Instead, they lead to a one-sided emphasis on price-based instruments and international emissions trading.

The research presented in this paper turns conventional wisdom upside down. It shows that if climate policies are focused on a productivity-enhancing least-cost approach, carbon-cutting investment shifts will result in substantial net economic gains — even before the benefits of avoided climate risks and damages are counted. Though mitigation will involve significant administrative and political challenges, meeting these challenges would bring ample economic rewards, especially for countries and regions that take early action.

A least-cost strategy: flexibility with no regrets

To be economically efficient, climate change mitigation needs to combine domestic action and international mechanisms in a cost-minimising fashion. This means that special emphasis has to be placed on so-called no-regrets options that reduce emissions while increasing GDP and/or economic welfare (before counting the benefit of avoided climate change).

In the domestic arena, one major no regrets policy option is a strategy of investment led productivity growth through market reforms. This strategy relies on incentives, standards, and voluntary agreements to remove market barriers against highly profitable energy efficiency investments and other ‘no-regrets’ technology options. Part of this universe are technology R,D&D programs. Like market reform programs aimed at existing technology, such programs offer above-market rates of return, ranging from several tens of percent to more than 100 percent per year.

A second major domestic no-regrets option is to raise energy prices through taxes or through a cap-and-trade emissions permit auction system while linking these measures to fiscal and subsidy reforms. Such fiscal reforms can lead to neutral or positive results on GDP if revenues from carbon taxes or permit systems are used to offset certain other taxes that disproportionately impede investment and employment. Such tax shifts also provide financing for R&D and programs to improve the markets for energy efficiency technologies while requiring no more than a small fraction of total revenues.

In the international arena, the major cost-reducing option is to expand the supply of low cost abatement opportunities beyond those available in the domestic economy. This is the ‘flexibility’ strategy of the Kyoto mechanisms. It lowers total mitigation costs by reducing the marginal cost of carbon abatement for countries with Kyoto commitments, and it can smooth cost-raising differences in marginal costs among individual Annex II countries.

If global greenhouse gas abatement is to be achieved at least cost, domestic market and fiscal reforms and international flexibility need to be pursued in tandem. This paper refers to such a least-cost approach as ‘flexibility with no regrets’.

Despite its fundamental economic significance, the ‘flexibility with no regrets’ strategy has been neglected in the international literature on mitigation cost economics and modelling. The lack of such analysis has to do in part with incompatibilities between aggregate economic (top-down) models on the one hand and highly disaggregated simulations of technology and market reform programs in individual sectors and end-uses (bottom-up models) on the other hand (IPSEP 1993).

The analysis summarised in this paper overcomes this dilemma through several modelling improvements and approximations.[1] Key among them is the disaggregation of GDP effects into those related to market reforms aimed at facilitating cost-effective energy efficiency improvements, and those related to carbon charges that increase the price of energy, as recently developed by Sanstad, DeCanio, and Boyd (2000). The market reform effect represents a move toward the economic efficiency frontier of the economy, while the price signals represent a shift along the trade-off curve between emissions and GDP. Other innovations concern the inclusion of learning curve effects, feedback effects on energy prices, co-benefits from reduced monetized externalities, and accounting for program implementation costs (IPSEP 2000, IWG 2000).

4. METHODOLOGY, SCOPE, AND ECONOMIC MODELING ISSUES

The degree to which present market patterns in providing energy services are economically inefficient, and the opportunity costs imposed on society by this inefficiency, have been explored in a large body of studies.[2] Two of the most recent and detailed such analyses that consider this issue in the context of climate change mitigation are the Clean Energy Futures (CEF) study covering the US and the IPSEP study covering the EU, respectively (IWG 2000, IPSEP 2000). For the purposes of the present analysis, these studies offer a convenient point of departure: In combination, they cover more than two thirds of carbon emissions in Annex II countries.[3] Their results can thus be extrapolated to all Annex II countries with reasonable confidence. With domestic least-cost action in Annex II countries quantified, the impact of such action on the international markets for emission allowances can be quantified as well.

We begin by summarising the main methodologies. This is followed by a presentation of the emission reduction and economic results from the two studies, reflecting a purely domestic mitigation strategy. As a next step, GDP impacts are modified to incorporate international allowance trading. And finally, the feedback effects of domestic action on international allowance prices and on developing countries are discussed.

Economic modelling components

In the analysis summarised here, the economic impacts of an integrated strategy of 'flexibility with no regrets' are conceptualised as the sum of five terms:

1. The GDP benefits from domestic market reforms;
2. The GDP losses triggered by increased final energy prices;
3. The GDP losses from purchasing international emission allowances;
4. The GDP benefits from tax shifts;
5. Co-control benefits in the area of air pollution and other classical environmental impacts of energy use.

For each of these five terms, a simplified methodology is used to estimate upper or lower limits that conservatively bias results toward lower GDP benefits and higher losses (IPSEP 2001a).

GDP benefits from domestic market reforms

The GDP benefits from market reforms are measured directly by the net savings in the total bill for energy services that these reforms bring about. The change in the total bill for energy services is taken directly from the two studies as reported there. It includes all marginal investments and program implementation costs, as well as the dynamic effects of mitigation programs on pre-tax energy prices and on energy demand. In both the CEF and IPSEP modelling studies, these feedback effects are explicitly accounted for through linkage of the analysis to partial equilibrium models.[4]

Energy system optimisation occurs on the basis of after-tax energy prices. As a result, the level of the carbon charge seen by the economy has an effect on the magnitude of savings. While most demand-side investments are robustly cost-effective at pre-tax energy prices, the energy supply mix becomes significantly more expensive as the carbon charge rises. However, in calculating net energy bill savings, any carbon charges or new energy taxes are excluded since they are merely a transfer charge from the viewpoint of the national energy bill. The impact of carbon charges on the economy is modelled separately.

GDP losses from price-induced substitution effects

Carbon taxes or emission allowance auctions under a domestic or international trading scheme lead to higher energy prices for fossil-based energy forms. This price increase triggers substitutions between energy, capital, and labour, and among energy carriers. This price-induced substitution effect temporarily reduces GDP growth in favour of emission abatement. Such losses can be categorised into long-term (equilibrium) effects, and short-term (transient adjustment cost) effects. Our focus in this paper is on the long-term effects.[5]

In the CEF study for the U.S., productivity-oriented market reforms are accompanied by a domestic permit trading scheme where all permits are sold at a price of 50$/tC. This carbon charge triggers price induced economic substitution effects. While reductions in energy demand due to increased energy productivity lead to lower energy prices than in the business-as-usual baseline, this price reduction is more than offset by the carbon charge. After-tax energy prices are slightly more expensive (heating oil and gas) to significantly more expensive (coal) than in the base case. Motor gasoline prices increase by 30 percent on account of a 'drive as you pay' insurance policy. The GDP losses from the substitution effects triggered by the 50$/tC charge are calculated on the basis of extensive top-down modelling studies and model comparisons conducted by the Stanford Energy Modeling Forum (EMF 1999).

In the IPSEP study for the EU, an energy tax is used in stylised form. While pre-tax energy prices decline on account of lower demand, the stylised tax maintains *after-tax* energy prices at baseline levels. The level of the tax varies by sector or energy carrier to reproduce baseline prices despite reduced demand. The emphasis on an energy tax over a carbon tax reflects the presence of a variety of externalised costs that are not related to climate change. This treatment means that GDP losses from price-induced substitution effects are zero and do not have to be considered.

Tax shift and subsidy reforms

In a combined strategy that involves both market reforms and significant reliance on permit sales or energy or carbon taxes, economic impacts are strongly shaped by the extent and nature of associated tax shifts. Using the revenue to reduce existing taxes may generate GDP benefits that partially or more than fully offset the GDP losses from higher energy prices (weak or strong double dividend), depending on which other taxes are being lowered (*e.g.*, taxes on payrolls, income, investment, *etc.*).

Though both studies reviewed here extensively discuss tax shift analyses for their respective regions, such shifts are not part of the formal analysis or quantified scenario results. In the case of the CEF analysis, GDP losses from substitution effects are instead based on the worst-case assumption of lump-sum recycling of carbon charge revenues.

In the IPSEP analysis, GDP losses from substitution effects are already zero as already mentioned. Nevertheless, energy tax revenues can be used for tax shifts and for funding market reform and R&D programs. The GDP benefits that would result from such fiscal and subsidy reforms are neglected. These treatments make the study's estimate of net GDP impacts more conservative.

International allowance trading

The modelling issues addressed so far were discussed in the context of a purely domestic abatement strategy. In an internationalised mitigation strategy, especially one that includes allowance trading with non-Annex I countries, more expensive domestic options of high positive cost can be substituted by lower-cost permits.

If the domestic strategy already involves a carbon charge, as in the case of the CEF study, this domestic carbon charge is replaced by a lower international allowance price. As a result, price-induced GDP losses (section "GDP losses from price-induced substitution effects" above) are reduced proportionately. Also, energy bill savings (section "GDP benefits from domestic market reforms" above) increase somewhat as the carbon price declines. Working in the opposite direction, domestic co-benefits of mitigation (see below) are reduced.

Finally, we introduce a simplification that represents a further conservatism. We treat the entire net expenditure for allowances as a GDP loss. In reality, some of this cost will flow back to the national economy through increased exports from the national economy to the sellers of allowances. This benefit is neglected in our calculations.

Ancillary benefits of carbon mitigation

Estimates of the co-benefits of carbon mitigation are available from a large body of literature. The figures used here reflect the medians of applicable ranges for the U.S. and EU. The IPSEP study includes estimates for the health and environmental benefits of reduced NOx and SO2 emissions. The CEF study provides physical estimates. These were translated into monetized welfare benefits for the purpose of this analysis.[6] As a conservatism, we exclude monetized estimates of climate change. We also do not attempt to monetize externalities other than classical environmental impacts, such as those related to energy security. Though we define the total impact of carbon mitigation as the sum of macroeconomic impacts and environmental co-control benefits, the latter may not register as changes in GDP per se. We refer to the combined GDP and monetized externality changes as the welfare impact of the scenarios.

5. SCENARIO RESULTS

Both the CEF and IPSEP analysis are based on widely used official reference or baseline projections. For the EU, the baseline is the ‘Hypermarket’ scenario of the European Commission (CEC 1996). Of the three baseline scenarios developed by the Energy Directorate, this scenario has the highest economic growth and carbon emissions. It reflects only energy policies adopted before 1996 and contains no policies to reduce carbon emissions.

For the U.S., the baseline scenario is the ‘Annual Energy Outlook 1999 Reference’ case of the U.S. Energy Information Administration (EIA 1998a). That case accounts only for policies in effect as of mid-1998. In the CEF study, this baseline was amended to reflect scheduled updates of energy efficiency standards and the anticipated impacts of steady funding levels for energy technology programs.

The common theme of both studies is that by emphasising domestic no regrets action, both the U.S. and the EU can realise large and growing reductions in carbon emissions at mildly to significantly negative net cost, *i.e.*, at a net economic benefit.

Energy use

Relative to official baseline projections of rising primary energy consumption, total fossil fuel use in 2020 declines by 21 percent in the U.S. and by 24 percent in the EU (see Table 1). Coal use declines the most, due to a shift to gas and other energy carriers especially in the power sector. Most new fossil-fired capacity is gas-fired and in the EU, based on energy-efficient cogeneration of heat and power. The contribution of renewable energy sources grows significantly.

In both the U.S. and EU scenarios, total reactor output declines significantly relative to the base year. However, in the U.S. study, reactor output increases somewhat relative to the business-as-usual forecast for 2020, on account of more favourable assumptions about relicensing and the cost of life extensions in the policy case. The role of nuclear power recedes in the EU scenario on account of a sustained moratorium for new plants and policies limiting the operating life of existing plants to 35 years. The IPSEP analysis further includes a comparison of historic rates of learning by doing and feasible future cost reductions per unit of time from very large, field-erected, long-lead time technologies like reactors on the one hand and small, modular, mass-produced, and very short lead-time technologies like wind turbines or solar cells. This analysis suggests that nuclear reactors do not represent an economically competitive technology option.

Table 1. Energy use in productivity-oriented policy scenarios for the U.S. and EU

		US analysis (IWG 2000) Advanced scenario 2020	EU analysis (IPSEP 2000) Productivity w. nucl. morat. 2020
Primary energy use relative to BAU		**-21%**	**-24%**
	Coal	-49%	-56%
	Petroleum	-21%	-23%
	Natural gas	-12%	-25%
	Nuclear	14%	-39%
	Renewables	27%	19%

Emissions

In the CEF scenario, the U.S. achieves most but not all of its Kyoto target through domestic action. Relative to the business as usual (BAU) case, emissions decline by 31 percent in the CEF scenario for the U.S. (Table 2). The U.S. realises 58-63 percent of its Kyoto target in 2010 (the target being a 7 percent reduction relative to 1990), and 85-90 percent of this same target in 2020 (Table 2). These reductions bring with them significant side benefits for clean air. BAU emission levels in 2020 are cut in half for sulfur dioxide, and by about 40 percent for nitrogen oxides.[7]

Table 2. Feasible reductions in carbon emissions from domestic actions in the US and the EU

	US analysis (CEF 2000) Advanced scenario			**EU analysis (IPSEP 2000)** Productivity & moratorium scenario			**US plus EU** Combined reductions		
	1990	2010	2020	1990	2010	2020	1990	2010	2020
BAU emissions, MtC	1346	1769	1922	863	970	1009	2209	2739	2931
Kyoto target, MtC		1252	1252		794	794		2046	2046
Emission reductions in the policy case, MtC		**517**	**670**		**176**	**214**		**693**	**885**
Policy case emissions, MtC		1443	1317		792	721		2235	2038
Emission reductions in the policycase, MtC		**326**	**605**		**178**	**288**		**504**	**893**
Change relative to BAU,%		*-0.18*	*-0.31*		*-0.18*	*-0.29*		*-0.18*	*-0.3*
Change relative to 1990, %		*0.07*	*-0.02*		*-0.08*	*-0.17*		*0.01*	*-0.08*
Fraction of Kyoto target realized		***0.63***	***0.9***		***1.01***	***1.34***		***0.73***	***1.01***

In the IPSEP scenario, the EU fully realises or substantially exceeds its Kyoto commitments, due in part, to a significantly lower rate of projected energy growth in the reference case. The scenario realises a reduction of 29 percent relative to year 2020 BAU levels (Table 2). With a reduction commitment of minus 8 percent relative to 1990, the EU just reaches this target in 2010, and then doubles the reduction to 17 percent below 1990 levels in 2020. Again, emissions of sulfur dioxide and nitrogen oxides are significantly reduced, cutting year 2020 BAU levels by 60 percent and 50 percent, respectively.

In combination, the U.S. and EU regions realise about 500 MtC in emission reductions by 2010, corresponding to about three quarters of their target for 2010. By 2020, they realise about 900 MtC, enough to fully meet their combined Kyoto commitments (Table 2). In first approximation, these findings can be extrapolated to the OECD region as a whole.

Economic impacts

Table 3 illustrates the basic methodology used for extending the CEF analysis for the U.S. (IPSEP 2001a). The table shows the business-as-usual development of carbon emissions between 1990 and 2010, and the emission reductions being achieved in the CEF scenario. These reductions are broken down by those resulting from non-price policies (market reforms), and those resulting from the $50/tC charge.

The table then shows the net GDP impact of achieving one and the same emission reduction level through alternative domestic policy packages. In the first column, a carbon charge is applied alone, and no tax shifts are included. This approach, which has dominated cost assessments in the U.S. and elsewhere, results in a significant GDP loss of 88 billion $/yr in 2010. After accounting for the ancillary benefits of domestic carbon mitigation, the net economic welfare impact is a loss of $76 billion (in constant 1997 U.S. dollars).

Table 3. GDP and welfare impacts of implementing 58 percent of the U.S. Kyoto target in 2010 – DOMESTIC ACTION

		BAU	EMF Mean	CEF Scenario	Least-Cost CEF Scenario		
Market reforms			NO	YES	YES	YES	YES
Carbon price ('97$)	$/tC	No C tax	134	50	50	50	50
Revenue recycling			Lump sum	Lump sum	Tax shifts	Tax shifts	Tax shifts
Offset of gdp losses caused by C charge	Fraction				0.50	1.00	1.5
Emissions							
Baseline U.S. emissions in 2010	MtC/yr	1769					
Emission reductions from market reforms	MtC/yr			-149	-149	-149	-149
Emission reductions from C charge	MtC/yr		-302	-153	-153	-153	-153
ternational allowance purchases to match CEF baseline	MtC/yr						
Remaining domestic C emissions in 2010	MtC/yr		1467	1467	1467	1467	1467
GDP and Welfare							
Net energy service bill savings in 2010	$billion/yr			48	48	48	48
GDP losses from substitution effects of C charge	$billion/yr		-88	-36	-36	-36	-36
GDP benefits from C tax shift reforms	$billion/yr				18	36	54
Domestic co-control benefits	$billion/yr		11	11	11	11	11
Purchase of international allowances	$billion/yr						
Net economic impact in 2010	$billion/yr		**-76**	**24**	**41**	**59**	**77**

The next column shows the CEF analysis without tax shifts. Here, market reforms create a $48 billion saving in energy service bills (net savings after accounting for investment and program costs). At the same time, the $50/tC charge causes a GDP loss of $36 billion. Again, tax shift policies are not included, so this economic substitution effect remains unmitigated. After accounting for ancillary benefits, the net impact on economic welfare is (48-36+11) = $24 billion/yr including rounding errors.

The next two columns show the effect of including tax shift reforms. At the low end, revenue recycling creates a 50 percent offset of the substitution effect. This corresponds to certain modelling results based on payroll tax reductions (EIA 1998b). At the high end, revenue generates a 150 percent offset of the GDP losses from the substitution effect.[8] On a net basis, the domestic policy package creates an economic welfare benefit of $41 to 77 billion/year, with a median of $59 billion/yr.

Table 3 thus illustrates the central significance of tax shift reforms in assessing domestic mitigation strategies that include carbon charges. While energy-productivity oriented market reforms may already overcompensate any GDP losses from substitution effects and create positive net impacts, tax restructuring shifts the balance decisively towards significant net economic benefits.

In the further representations of GDP impacts below, we assume that tax shifts are implemented (unless indicated otherwise in the column headings), and that the GDP benefits of tax shifts just offset the GDP losses from energy price effects. This corresponds to a midpoint between a weak double dividend and a strong double dividend. For this midpoint, which leaves significant flexibility in the design of tax reforms, the net GDP impact becomes equal to the energy bill savings produced by market reform programs (section "GDP benefits from domestic market reforms", chapter 4 above). Since these savings are a central output of bottom-up modelling studies, the derivation of the GDP impacts implied in these studies requires no further macroeconomic modelling analysis for this assumption. It therefore provides a convenient point of reference.

Table 4. GDP and welfare gains from domestic carbon mitigation – Annex II

	Net benefit of domestic least-cost mitigation		
	GDP benefits	Externalities Billion $'97/yr	Total
Year 2010			
US	48	13	61
EU	75	20	95
Rest of Annex II (extrapolated)	47	13	60
Annex II total	170	46	**216**
Year 2020			
US	108	20	128
EU	170	30	200
Rest of Annex II (extrapolated)	109	20	129
Annex II total	387	70	**456**

Exchange rate 1 Euro = 1 dollar

Extrapolation to Annex II

Again using the above assumption on tax shift effectiveness, Table 4 shows the net GDP and externality benefits for the U.S. and EU, with an extrapolation to the rest of the Annex II countries.[9] In 2010, the total Annex II gain is more than $200 billion/yr. By 2020, this figure grows to more than $450 billion/year, on account of further penetration of energy efficiency investments.

During the five years of the first Kyoto commitment period (2008-2012) Annex II countries could reduce their total energy service costs by $760 billion, equivalent to 1 percent of projected GDP. In 2020, estimated savings reach 1.75% of GDP.

6. THE MARGINAL BENEFIT OF GLOBAL TRADING IN A LEAST COST CONTEXT

Because most discussions of international allowance trading are based on comparisons with grossly suboptimal domestic tax policies that exclude market and fiscal reforms,[10] the benefits of such trading are grossly overstated. The true marginal benefit of global trading must be calculated in a least-cost context *i.e.*, when trading and market and fiscal reforms are applied in combination (IPSEP 2001b).

In calculating the *incremental* cost reduction impact of global trading, domestic market and fiscal reform policies need to be applied first since they yield the larger cost reductions and realise emission reductions at negative net cost. As the marginal policy, international trading merely enhances the net economic gains obtainable in a purely domestic no regrets strategy.

Table 5. Economics of fully implementing the U.S. Kyoto target in 2010: DOMESTIC ACTION

		BAU	**Domestic mitigation strategies**		
			EMF Mean	CEF Extended Scenario	
Market reforms			No	YES	YES
Carbon price ('97$)	$/tC		230	136	136
Revenue recycling			Lump sum	Lump sum	Tax shifts
Offset of gdp losses caused by C charge	fraction				1.00
Emissions					
Baseline U.S. emissions in 2010	MtC/yr	1769			
Emission reductions from market reforms	MtC/yr			-149	-149
Domestic permit auction	MtC/yr		-517	-369	-369
Remaining domestic C emissions in 2010	MtC/yr		1252	1252	1252
GDP and Welfare					
Net energy service bill savings in 2010	$billion/yr			29	29
GDP losses from substitution effects of C charge	$billion/yr		-133	-88	-88
GDP benefits from C tax shift reforms	$billion/yr				88
Domestic co-control benefits	$billion/yr		19	19	19
Purchase of international allowances	$billion/yr				
Net economic impact in 2010	$billion/yr		**-113**	**-40**	**48**

In such a marginal benefit analysis, the economic significance of international trading is dramatically reduced. This effect is illustrated in Tables 5 and 6, which show an extension of the findings of the Clean Energy Futures study for the U.S. to the complete implementation of the U.S. Kyoto target by means of international allowance purchases (IPSEP 2001b).

The reference point is again the cost impact of a purely domestic carbon tax or cap-and-trade permit auction strategy that excludes fiscal and market reforms. Based on the mean of the Energy Modeling Forum results, implementing Kyoto would require a carbon tax of $230/tC, and would result in economic losses of $113 billion/year in 2010.

When the domestic carbon charge is applied in combination with domestic market reforms, the required carbon charge to reach the Kyoto target is lowered to $136/tC (Table 5). This figure is again based on the mean results of the U.S. Energy Modeling Forum. At $29 billion/year, net energy bill savings from the market reforms are now lower than in the CEF scenario with a $50/tC tax, because the higher tax brings about more investments in more expensive energy supplies. At the same time, the higher carbon tax produces a higher GDP loss from substitution effects. After accounting for environmental co-benefits, the result is a net loss in economic welfare of $40 billion/yr.

When tax shifts are added to this scenario case, this loss is converted into a $48 billion/year gain. The total benefit of shifting from a domestic tax to a least-cost mix of domestic market and fiscal reforms thus is $48 + 113 = $161 billion/yr. International trading schemes must be measured against this figure.

Table 6. Economic impacts of implementing the U.S. Kyoto target: INTERNATIONAL STRATEGIES

		BAU	Domestic	International mitigation strategies		
			EMF Mean	EMF Mean w. global trading		CEF/Kyoto Scenario
Market reforms			No	No	No	YES
International carbon price ('97$)	$/tC			41	41	11
Domestic permit price ('97$)	$/tC		230	41	41	11
Revenue recycling			Lump sum	Lump sum	Tax shifts	Tax shifts
Offset of gdp losses caused by C charge	fraction				1.00	1.00
Emissions						
Baseline U.S. emissions in 2010	MtC/yr	1769				
Emission reductions from market reforms	MtC/yr					-149
Total reductions from permit purchases	MtC/yr			-517	-517	-369
Domestic permit auction	MtC/yr		-517	-91	-91	-36
International allowance purchases	MtC/yr			-426	-426	-332
Remaining domestic C emissions in 2010	MtC/yr		1252	1678	1678	1584
GDP and Welfare						
Net energy service bill savings in 2010	$billion/yr					54
GDP losses from substitution effects of C charge	$billion/yr		-133	-25	-25	-6
GDP benefits from C tax shift reforms	$billion/yr				25	6
Domestic co-control benefits	$billion/yr		19	3	3	7
Purchase of international allowances	$billion/yr			-17	-17	-4
Net economic impact in 2010	$billion/yr		**-113**	**-39**	**-14**	**57**

The impact of international trading is shown in Table 6. The chart first shows that global emission allowance trading alone does indeed yield a large cost reduction when measured against purely tax-based domestic strategies without tax shifts: losses of $113 billion are reduced to $39 billion/year in 2010. Reductions in the price-induced substitution effects far outstrip the cost of international allowances or the foregone domestic co-benefits. When tax shifts are added, the net result becomes a small loss of 14 billion/year in 2010.

A very different picture emerges when international trading is evaluated against the reference point of domestic least cost action as quantified in Table 5 above. In that case, global trading brings only a small marginal gain: benefits of $48 billion/year from a purely domestic strategy are increased to $57 billion/yr.[11] Larger domestic co-control benefits, lower demand for and cost of international purchases, and greater energy bill savings all contribute improvements.

However, against the $162 billion/year improvement that is already obtainable from domestic least-cost mitigation, this $11 billion/year gain is merely a roughly 7 percent effect. About 93 percent of feasible abatement cost reductions are contributed by domestic reform policies. The claim of large cost reductions from global emissions trading thus turns out to be an artifact produced by the neglect of domestic market and fiscal reforms in conventional modelling studies.

However, international trading does add some benefit in that it narrows the uncertainty range in the above results.[12] It adds a backstop to domestic policy reforms in case these should turn out to be politically more difficult. Of course, this backstop should not be over-emphasised, since the international trading mechanisms are untested and present risks of failure of their own.

International trading might also be seen as a tool for technology transfer to the developing nations, and the loss thereof as a setback. Here, it must be kept in mind that the large-scale implementation of energy-efficiency oriented market reforms in the Annex II countries will have major spill-over effects into the developing countries. The main driver of technology transfer — foreign direct investments by OECD-based multinationals — will become a transmission belt for no-regrets technologies such as hybrid cars or high-efficiency appliances and industrial processes rather than for standard versions of these technologies. As shown in other work, the net economic benefits of an Annex II least-cost strategy emphasising market and fiscal reforms for developing countries are likely to be at least as large or several times higher than those of a global emissions trading regime without such reforms (IPSEP 2001a).

7. THE OPPORTUNITY COST OF EXCESS EMISSIONS TRADING

Against findings of large feasible savings from domestic energy productivity investments, conventional proposals to meet Annex II commitments mostly through the Kyoto mechanisms suddenly become expensive: Allowing most Annex II emission reductions to be realised through "elsewhere" mechanisms would create significant opportunity costs for Annex II consumers and businesses. Rather than obtaining emission reductions at negative net cost from domestic action, they would end up paying for investments abroad that provide carbon reductions at a positive cost. The fact that this cost may be lower than it would have been without international emissions trading does not change the fact that excess trading and lack of domestic action result in an economic penalty for Annex II countries.

Developing countries could also be put at a disadvantage. To achieve climate protection at least cost, the economically and technologically dominant Annex II countries need to take the lead in raising energy efficiency by implementing a series of domestic market reforms. Such domestic programs will trigger highly profitable productivity investments. Furthermore, they will accelerate low-carbon technological innovation. These will spill over into the rapidly growing capital stocks of developing countries, bringing early productivity benefits to them as well.

A one-sided reliance on "elsewhere" flexibility would work in the opposite direction. It would slow and undermine the crucial process of productivity investments and low-carbon technological innovation in Annex II countries. It would also keep developing countries onto a more expensive and more carbon-intensive development path.

8. SOLVING THE KYOTO QUANDARY

The finding that climate change mitigation can be made into a profit center and that the Kyoto mechanisms are less significant could lead to the perception that the Kyoto treaty itself might be less important. If carbon mitigation can become a global profit center, why persist in vexing international negotiations?

Such a dismissal of the Kyoto Protocol would be a misreading of the research presented here. There are at least three major reasons why the Protocol is crucial if progress is to be made in combating climate change. First, the environmental targets of the treaty are needed as a driver for the political process in each country. In the absence of specific commitments, it is more likely that market reforms will be delayed or thwarted by vested interest groups. Second, for this environmental driver of policy action to persist over time, national commitments need to be supported by an effective compliance regime. Third, while the Kyoto mechanisms are much less significant than previously thought, they may nevertheless offer an important backstop function for some countries.

At the same time, a no regrets oriented flexibility strategy offers fundamental new perspectives and solutions for strengthening the UN FCCC process. First and foremost, it makes more ambitious greenhouse gas reduction targets not only economically affordable, but also attractive. In doing so, it returns attention to the fundamental environmental purpose of the UN Framework Convention. The energies now devoted to the procedural details of the Kyoto mechanisms can be productively redirected in a more forward-moving manner.

A strategy of ‘flexibility with no regrets’ also offers economic protection against the risks of “overcommitments” perceived in some countries if growth should be stronger than anticipated. Because such growth would itself be based on higher energy and total factor productivity, net economic gains from mitigation would result over a wide range of targets, time horizons, and growth rates.

Finally, a no regrets productivity strategy allows developing nations to join the fight against global warming while enhancing their economic and social development — precisely the outcome envisioned in the Convention.

9. REFERENCES

Abt and Pechan-Avanti 1999, *Co-Control Benefits of Greenhouse Gas Control Policies,* prepared for Office of Policy, U.S. Environmental Protection Agency, Washington, DC.

Boyd, R., K. Krutilla, W.K. Viscusi 1995: "Energy Taxation as a Policy Instrument to Reduce CO2 Emissions: A Net Benefit Analysis", *Journal of Environmental Economics and Management* 29(1), 1-25.

CEC 1996, *European Energy to 2020: A Scenario Approach,* Special Issue of *Energy in Europe,* Energy Directorate of the European Commission, Bruxelles, Spring.

EIA 1998a, *Annual Energy Outlook 1999*, DOE/EIA-0383 (99), Washington, DC., July.

EIA 1998b, *Impacts of the Kyoto Protocol on U.S. Energy Use and Economic Activity,* Energy Information Administration, SR/OIAF/98-03 Washington, DC.

EMF 1999: *The costs of the Kyoto Protocol: A multi-model evaluation.* 16^{th} Energy Modeling Forum, Energy Journal, Special Issue.

Haites, E. 2000: *Institutional features of the Kyoto Mechanisms and the COP-6 Decisions,* Margaree Consultants, Inc., Toronto.

IPCC 1996, *Climate Change 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge/New York.

IPSEP 2001a, *Solving the Kyoto Quandary: Flexibility with No Regrets,* International Project for Sustainable Energy Paths, El Cerrito, CA. http://www.ipsep.org

IPSEP 2001b, *Cutting Carbon Emissions at a Profit: Opportunities for the U.S.,* International Project for Sustainable Energy Paths, El Cerrito, CA. http://www.ipsep.org

IPSEP 2000, *Cutting Carbon Emissions While Making Money: Climate Saving Energy Strategies for the European Union,* International Project for Sustainable Energy Paths, El Cerrito, CA. http://www.ipsep.org/Carbon.pdf

IPSEP 1993, *Cutting Carbon Emissions: Burden or Benefit?* Report to the Dutch Ministry of Housing, Physical Planning, and Environment. International Project for Sustainable Energy Paths, El Cerrito, CA.

IWG 2000, *Scenarios for a Clean Energy Future.* Interlaboratory Working Group on Energy-Efficient and Clean-Energy Technologies, Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-476 and LBNL-44029, Oak Ridge, TN and Berkeley, CA. November.

Krause, F. 1996: "The Costs of Mitigating Carbon Emissions: A Review of Methods and Findings from European Studies," in *Energy Policy,* Special Issue on the Second UN IPCC Assessment Report, Working Group III, Vol. 24, Nos. 10/11, pp. 899-915.

Laitner, John A. 1999: "Modeling the Influences of Technology Policy, Organizational Structure, and Market Characteristics on the Economic Evaluation of Climate Change Policies," in *Proceedings, ACEEE Industrial Summer Study,* Saratoga Springs, NY. June.

Sanstad, A., S. DeCanio, G. A. Boyd 2000: "Estimating Bounds on the Macroeconomic Effects of the CEF Policy Scenarios" Appendix E-4 in: *Scenarios for a Clean Energy Future.* Interlaboratory Working Group on Energy-Efficient and Clean-Energy Technologies, Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-476 and LBNL-44029, Oak Ridge, TN and Berkeley, CA. November.

Wigley, T., R. Richels, and J. Edmonds 1996: "Economic and environmental choices in the stabilization of atmospheric CO2 concentrations," *Nature* 379: 240-243.

10. END NOTES

[1] Important progress in formally integrating behavioral, technological, and market reform analysis is discussed in Laitner (1999).

[2] See the review of bottom-up studies in IPCC (1996), Chapter 9, and Krause (1996) for studies covering Western Europe.

[3] Annex II countries essentially are the wealthy OECD countries with Kyoto commitments, as distinct from all countries with Kyoto commitments (Annex I), which include the former Soviet Union and other countries.

[4] In the U.S. case, this is a reduced form of the DRI-NEMS model of the Energy Information Administration. In the EU case, energy price feedbacks are based on outputs from the MIDAS model of the European Commission.

[5] As pointed out by Sanstad, DeCanio, and Boyd (2000), transient adjustment costs can be largely or entirely offset or avoided through monetary policy and fiscal policy measures.

[6] See the ranges developed by Abt and Pechan-Avanti (1999) and by Boyd *et al.* (1995).

[7] The reductions in carbon emissions reported here apply to the 'Advanced' scenario. The higher values of the indicated ranges include additional reductions from cogeneration that are identified in the summary of the IWG (2000) report but were not included in the tabulated scenario runs.

[8] This value is a representative figure based on a review of recent research on strong double dividend tax recycling. That research shows that environmental taxes result in a strong double dividend on account of the widespread tax subsidies and tax exemptions, such as mortgage interest payments. In earlier work that questioned the feasibility of a strong double dividend, these distortions had not been taken into account. Also, cutting taxes on investment has been shown to generate strong double dividends. See the CEF report (IWG 2000), Appendix E.4 for a review.

[9] The figures are expressed as the net present value in year one over the five year commitment period beginning, respectively, in 2008 and 2018. A discount rate of 5 percent is used. All prices are in constant 1997 U.S. dollars.

[10] See, e.g., Wigley *et al.* (1996).

[11] The $11/tC price is a modeling result obtained with the international allowance price model of Haites (2000). It reflects two effects: (1) the reduction in demand for allowances on account of profitable domestic Annex II opportunities, which reduces the contribution of international mechanisms from about 70 percent to 30 percent of Annex II commitments; and (2) the relative abundance of ‘hot air’ allowances at a very low price when demand is low.

[12] See IPSEP (2001b) for a full sensitivity analysis.