

# E3 Network: Economics for Equity and the Environment

## Climate Economics Taskforce

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## INTRODUCTION

E3 is a new network of economists who are developing and applying economic arguments for active protection of human health and the natural environment. E3 emerged from a series of conversations between economists, representatives of the environmental community, and members of the philanthropic community on the need to strengthen and bring to the fore economic analysis that can better address the complex realities of real-world environmental problems.

Our network of economists believes that economic analysis of the environment cannot be separated from issues of social justice. We are critical of economics that remains agnostic on issues of intra- and inter-generational equity, and economics that perpetuates the myth that protection of the natural environment and economic well-being are competing goals.

We also believe that useful new economic theory will arise only if economists engage with practical, real-world problems. As economists, we are unsatisfied with abstract theorizing for its own sake and with economic analysis that is largely inaccessible to non-economists engaged in policy and advocacy work.

We are dismayed that the public discourse on environmental issues and climate change especially, has become dominated by a perspective with an anti-regulatory, anti-reform bias. That perspective has become the leading ideological justification for doing less rather than more to protect people and the environment, and for redistributing income and wealth toward polluters.

E3's newly formed Climate Economics Taskforce joins professional economists for the purposes of forging an aggressive response to climate change that is firmly rooted in science and in E3's commitment to social justice, and debunking the analyses of climate skeptics who conclude that the "optimal" response to an impending global crisis is to do almost nothing at all.

We know that environmental advocates have to be able to fight fire with fire, numbers with numbers, and bad theories with good theories. In the pages that follow, our Climate Economics Taskforce demonstrates that there are effective counter-arguments to those that currently dominate the climate debate. We formulate the case against inaction, illuminate the importance of innovations policies and social dynamics, argue persuasively for a cap-and-auction approach to climate policy, and stress the need for international cooperation in response to climate change.

For more information about E3 Network and our Climate Economics Taskforce, please visit our website at [www.e3network.org](http://www.e3network.org).

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# THE CASE AGAINST INACTION

## I. Economics is not the Right Language for Addressing Climate Change

Why is the debate over what to do about climate change formulated mainly in terms of economics? Economics is not the standard discourse in other cases in which fundamental values are at stake, nor is it the ruling principle in most of life's important decisions.

There are several reasons for the prominent role of economics, some more respectable than others:

1. The cost-benefit framework is an appealing way to frame policy questions in a diverse and pluralistic society, at least in cases involving ordinary goods where everyone can agree that "more is better." This relatively mild type of agreement allows the Kaldor-Hicks compensation principle to be deployed: A policy change is beneficial if the winners can compensate the losers and still have something left over. In practice, these compensating payments are rarely made, but the gains and losses tend to balance out over a large number of marginal policy moves, provided one group does not maintain a monopoly of power or exercise undue influence on the decision-making process.

In the climate case, however, the main beneficiaries of the policy are likely to be future individuals who do not yet exist. Even if they did, there is no way they could transfer some of their gains back to us in the present, because time travel is impossible. Hence, the consensus-building Kaldor-Hicks compensation rule cannot be invoked. Economic cost-benefit calculations going beyond Kaldor-Hicks require very strong utilitarian assumptions allowing comparison of the consumption of different individuals living at different times and places, with different standards of living, prices, technologies, environments, and cultures. This necessitates various versions of discounting (to compare present and future consumption), indexing (to compare situations with different bundles of good and different prices) and direct interpersonal comparisons (as between rich and poor people in the present). The assumptions required to carry out these calculations are far more contestable than the simple Kaldor-Hicks rule.

These very strong utilitarian assumptions must be made in order to cast the climate policy problem as one of maximization of a mathematical objective function. The "benefit" to this formulation is that it allows economists to pretend that the policy problem can be solved by numerical calculations akin to those carried out by natural scientists. The first-order conditions for maximization and the market-clearing restrictions that place limits on the goods that can be produced and consumed have the appearance of the laws that constrain the outcomes of physical processes. However, economic problems are fundamentally different because (1) human agents (and their social systems) are capable of genuine choice, unlike physical systems, and (2) the background "givens" (such as human preferences, technological possibilities, and property rights) that are needed to make the maximization problem well-defined are not really given at all, because they are subject to choice and change.

2. The economics framework has a tendency to submerge ethical questions beneath technical details, and to transform moral questions into technical ones in a non-transparent or invalid way. Thus, intergenerational equity is *prior* to technical issues of discounting, and to convert the intergenerational equity problem into one of choosing a discount rate entails the concomitant adoption of numerous assumptions of strong utilitarianism and interpersonal comparisons (see #1 above). Similarly, the "representative agent" approach (which is usually necessary because of computational or informational limitations) covers over substantive assumptions about distribution of property rights and the operation of labor and capital markets within societies and across nations.

The standard economic assumptions (that only absolute and not relative consumption matters for utility, that agents can formulate far-seeing plans rationally, that production is organized optimally, etc.) all embody judgments about human beings and human organizations that are not well-supported by the evidence.

Clarity is lost when these matters of ethics and value are transformed into seemingly technical issues. Paradoxically, it may be easier to gain agreement on some of the underlying moral principles (i.e., our duty to the future, provision for a social safety net for the weak, promoting opportunities for social and economic mobility, orientation towards “sustainable development”) than on the technical features of mathematical models embodying differences of principle in a non-transparent fashion.

3. Couching the climate policy problem primarily in economic terms gives economists disproportionate influence in the debate, so it is in economists’ personal and professional interest to formulate the debate in economic terms. Mastering the technical apparatus of contemporary economics is an unacceptably high hurdle for participation. Achieving the right balance between scientific expertise and popular participation in the political arenas of modern mass societies is by no means easy or straightforward. Technical knowledge is essential for informed discussion many issues and public ignorance is a huge barrier to good decision-making, but at the same time expertise can serve as an excuse for self-aggrandizement. This is not to say that economists are any more power-hungry than others; rather, the tension between expertise and participation is one of several deep governance problems plaguing the modern world.

Even if economics ought not be the sole (or even the primary) ground upon which climate policy is debated, it should not be overlooked that there is a great deal of agreement among almost all economists about the main features of the problem. The emission of anthropogenic greenhouse gases constitutes an environmental externality, so some restriction of emissions would increase market efficiency; the externality is global, so coordinated international action is the most effective means of correcting it; and the significance of low-probability, high-impact catastrophic climate risks needs to be a major element in formulating policy. Multiple analytical routes lead to broad conclusions of this type, and economists can enhance their credibility (and helpfulness) by maintaining an appropriate degree of methodological humility.

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## II. The Stern Review vs. its Critics: Which Side is Less Wrong?

In the Stern Review, released in late 2006, a team headed by Sir Nicholas Stern reviewed the economics of climate change, at the request of the British government.<sup>1</sup> Stern and his colleagues expressed alarm at the impending climate damages that will result from business as usual, and presented economic arguments endorsing prompt and vigorous action. In Stern's view, inaction on climate change would lead to damages worth at least 5% of world output per year, and, depending on how the damages are calculated, perhaps as much as 20%. Most of these damages could be prevented, according to Stern, by spending 1% of world output annually on mitigation.

Other economists were quick to respond, often quite critically. Conventional economic analysis typically recommends doing much less, and more slowly, in order to avoid dampening the prospects for economic growth. This brief evaluates the economists' debate over the Stern Review.<sup>2</sup> While neither side has a credible answer in every respect, a review of the debate shows that on at least three crucial questions, Stern is "much less wrong" than his critics in academia.

**1. The discount rate** is central to the economics of climate change. When costs are incurred to reduce emissions today, the benefits of reduced climate change will occur decades or centuries later. How much less valuable are those benefits, because they will happen in the future? At a discount rate near zero, future benefits are almost as valuable as if they occurred today, implying that it is "worth it" to take action now to secure those future benefits. At a high discount rate, future values fade rapidly into insignificance, implying that very little climate mitigation is "justified" by its (heavily discounted) benefits in generations to come.

Economic theory distinguishes between two components of the discount rate: the "rate of pure time preference" that would apply if all generations had equal incomes; and a growth-related rate, assuming that if the future will be richer than the present, then there is less need to make investments on their behalf today.

Stern endorses the philosophical argument that present and future generations are of equal ethical standing, implying that pure time preference should be zero. Your granddaughter is no less important than your daughter simply because she will be born a generation later. Other economists frequently object that people display impatience and short time horizons at a level incompatible with zero pure time preference. Moreover, a rate of precisely zero causes technical problems in some economic theories. Perhaps to avoid this technical issue, Stern introduces a miniscule rate of pure time preference, 0.1% per year, based on an arbitrary estimate of the annual probability that the human race will not survive.

Like other economists, Stern includes a second part of the discount rate, tied to economic growth. His discount rate thus becomes the rate of growth of per capita consumption, plus 0.1%. Since economic growth averages 1.3% in his model, his discount rate averages 1.4%. Other economists assume both a more substantial rate of pure time preference, and a larger growth-related component, yielding discount rates as high as 6%. The difference this makes is enormous: \$100 of benefits 100 years from now would be worth \$25 today at a discount rate of 1.4%, versus \$0.25 at 6%. In short, economic analysis can "see" much more of the future at a discount rate as low as Stern's, but becomes myopic at a rate as high as 6%.

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<sup>1</sup> The Stern Review is available on-line, with background and other related documents, at [http://www.hm-treasury.gov.uk/independent\\_reviews/stern\\_review\\_economics\\_climate\\_change/sternreview\\_index.cfm](http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm).

<sup>2</sup> This brief is based on a much more extensive, forthcoming report for Friends of the Earth-UK.

**2. Uncertainty** is also crucial to understanding climate change – both because of what we don't know, and also because of what we do know. Temperature, rainfall, and other climate impacts are becoming more variable; floods, droughts, and storms are getting worse, although they are not predictable in detail. As temperatures rise, so does the risk of an irreversible catastrophe, such as the loss of a big ice sheet in Greenland or Antarctica, even though the probability of such catastrophes is not precisely known in advance. Most economic models, nonetheless, rely on best guesses about future climate impacts, treating those guesses as established facts.

The Stern Review explicitly includes uncertainty, using what is called “Monte Carlo analysis.” Many critical features of climate science and economics are assumed to be uncertain; each time the model is run, the computer effectively rolls the dice and picks a different value for the uncertain features. The model is run 1000 times, and the results are averaged to produce the final estimates of climate damages. In some runs the impact of climate change is milder than the average expected value, and in some runs it is more severe. The effect of this treatment of uncertainty is quite large; replacing the Monte Carlo analysis with fixed, best guesses, as in most other models, would have the same bottom-line effect as doubling the discount rate.<sup>3</sup>

The Stern approach shows the effect of assuming a broad, but somewhat arbitrary, range of uncertainty in climate analysis. It is impossible to believe that the Stern team knew the exact extent of uncertainty about the dozens of features that are allowed to vary in their model. Indeed, they likely assumed far too little uncertainty on some key points, as suggested below.

**3. Costs and benefits** of reducing carbon emissions are an additional source of contention, with many economists claiming that Stern set the costs too low, and/or the benefits too high. Some of Stern's critics in this area, including Bjorn Lomborg, and a team of prominent British critics, echo the claims of the “climate skeptics” who want the world to stop worrying about climate change. In fact, the Stern Review and its well-researched background papers are consistent with IPCC and other reports. There is no hard evidence that Stern has exaggerated the extent of crisis.

If there is a problem, it is in the opposite direction: on some important questions, Stern relied too heavily on existing economic research and models, including an analysis that gives low estimates of the probability and costs of catastrophic changes. While the text and diagrams of the Stern Review suggest that the risk of losing the Greenland ice sheet is noticeable at 2° of warming, and severe by 3°, the Stern economic model assumes no risk of catastrophic damages below a threshold that varies from 2° to 8°, with 5° the most common value.<sup>4</sup> A model that took seriously the warnings about catastrophe in Stern's text would reach even stronger conclusions about the need for immediate action to reduce emissions.

## Summary

A reasonable economic analysis of climate change requires a discount rate roughly as low as Stern's, in order to “see” the future; a broad treatment of uncertainty, something like Stern's, to reflect current scientific knowledge of the problem; and rigorous examination of expected damages, which are likely to be even greater than Stern suggested. While no one is exactly right on every question, Stern is “much less wrong” than most of his critics.

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<sup>3</sup> See the sensitivity analyses in Simon Dietz et al. (the Stern team's response to critics), in *World Economics* vol. 8 no. 1: Using the modal value for each Monte Carlo parameter has about the same effect as adding 1.4 percentage points to the pure rate of time preference (i.e. raising the average discount rate from 1.4% to 2.8%).

<sup>4</sup> See Paul Baer, “The Worth of an Ice Sheet.”

### III. Discounting, Uncertainty, and Climate Change

#### Some Fundamentals

In the theory of cost-benefit analysis, the *discount rate* represents the return on investment required to justify the expenditure of scarce social resources. This in turn reflects decision-makers' impatience or *time preference*—the degree to which they prefer to receive benefits in the present rather than the future.

In the economics of climate change, one key argument is that the future benefits provided by greenhouse gas emissions abatement should be discounted at a rate equal to the average return on a typical private-sector investment (Manne, 1999). The rationale is that resources should be allocated to uses that provide the greatest benefits to society. Historical data suggest that typical private-sector investments yield real (inflation-corrected) returns of 6% per year (Nordhaus, 1994). Yet the use of a 6% discount rate has strong consequences in the evaluation of climate change policy regimes. It implies that:

1. No more than \$0.003X should be spent today to avoid environmental impacts that would impose \$X of damages one century in the future.
2. Greenhouse gas emission should be allowed to grow at a robust rate.

In one example of this approach, Nordhaus and Boyer (2000) find that carbon dioxide emissions would rise by 64% between 2005 and 2105 given optimal climate change policies. Under business-as-usual, emissions would rise by 85%. The inference is that it is better for society to bear the long-term costs of climate change than the short-run costs of climate stabilization. This conclusion contradicts the primary goal of the U.N. Framework Convention on Climate Change, which calls for major and sustained emissions reductions to “prevent dangerous anthropogenic interference with the climate system.”

#### Intergenerational Fairness

Critics charge that the use of high (c. 6%) discount rates can support policy outcomes that are unfair to future generations. One line of argument holds that climate change would impose major, uncompensated costs on posterity. This violates the moral principle that our children and grandchildren have a right to: (a) inherit an undiminished natural environment; or (b) protection from uncompensated environmental harms (Brown, 1998). The claim here is not that high discount rates fail to capture individuals' time preference, but rather that individuals' time preference is irrelevant in considering questions of intergenerational fairness.

A second argument is grounded in utilitarian moral reasoning, which holds that equal weight should be attached to the welfare of each present and future person. Stern (2007) argues that this moral premise is consistent with the use of a 1.4% discount rate in monetary cost-benefit analysis. This holds true because, in a world of economic growth, the welfare provided by an extra dollar of income should decline over time. Economists have long recognized that the use of low (c. 1%) discount rates supports aggressive steps to stabilize global climate (Cline, 1992). The utilitarian defense of low discount rates, however, is controversial because it rests on contested moral judgments and scientifically untestable assumptions about the relationship between affluence and welfare (Manne, 1995).

#### Discounting and Uncertainty

The use of low discount rates can be justified without appeals to principles of intergenerational fairness. Suppose that one accepts the view that public policies should be evaluated using the same discount rates employed in private-sector decisions. While it may be true that a typical private-sector investment generates an

average return of 6% per year, it is also true that financial markets provide a wide array of investment options with widely varying rates of return. In particular, investors demand:

- 1% returns on safe (or “risk-free”) investments such as money market funds.
- 2% returns on low-risk investments such as long-term, high-quality bonds.
- 7% returns on risky investments such as corporate stocks.

In theory, the discount rate employed in cost-benefit analysis should reflect the risks presented by the policy under investigation. The appropriate discount rate is equal to the sum of two terms: (a) the risk-free rate of return; and (b) a risk premium.

In the case of the stock market, the risk premium assumes a large, positive value. This is because investing in stocks increases the overall volatility associated with an investor’s portfolio. The risk premium represents the compensation that investors demand to accept the prospect of potential losses.

Greenhouse gas emissions abatement, in contrast, would serve to reduce potentially catastrophic risks. The impacts of climate change are only partially understood and are subject to key uncertainties. But by reducing climatic risks, emissions abatement is akin to an insurance policy. Economic theory implies that the risk premium should be *negative* for policies that reduce major risks to future economic welfare (Howarth, 2005). From this it follows that the discount rate employed in evaluating the net benefits of climate change policies should be no higher than the risk-free rate of return.

This line of reasoning supports the use of low ( $\leq 1\%$ ) discount rates in the economics of climate change based purely on an analysis of decision-makers’ behavior in capital markets. Data from financial markets suggest that people have: (a) low rates of time preference; and (b) high rates of risk aversion. Accounting for these facts favors aggressive steps to stabilize global climate.

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#### **IV. Towards Greater Transparency in Climate Economics: Deconstructing DICE-2007**

Today's scientific models of climate change have achieved remarkably detailed forecasts of future climatic conditions, with a gradually increasing degree of consensus between models. In the realm of economics, however, there is much less agreement about the laws and patterns that will govern future development. Numerous economic models weigh the costs of allowing climate change to continue against the costs of stopping or slowing it, and thus recommend a "best" course of action: one that, given the assumptions of the model, would cause the least harm. But there is little indication of an impending accord among climate economists.

The results of climate economics models depend on facts about the physical world, on theories about economic growth, and on ethical and political judgments. To the extent that climate policy relies on the recommendations of economic models, it is vulnerable to assumptions hidden in their inner workings. It is, therefore, of paramount importance that the economic models that shape our climate policy be not only as accurate and up-to-date as possible in their scientific content, but also as transparent as possible in their ethical, political, and economic content.

Perhaps the best-known and most influential climate economics model, William Nordhaus' Dynamic Integrated model of Climate and the Economy (DICE), links a simple representation of the climatic impacts of greenhouse gases to a simple representation of economic growth, driven by a process designed to maximize economic well-being. The DICE climate and economic models share two feedback mechanisms: a damage function, relating temperature increase to economic and social costs; and an abatement function that describes the costs associated with reducing carbon emissions. The recent update (2007) of DICE yields a basic forecast of the "social cost of carbon" (SCC) – the combined current and future impacts of an additional ton of carbon – of \$21/tC in 2005 or \$216/tC in 2105. The implication is that any abatement policy that cost less than this would result in a net benefit to society. DICE recommends a gradual increase in emission controls to achieve completely carbon-free production in 2235, with the increase in global mean temperature reaching 3.3° (above year 1900) in 2215 before beginning to decline. Following this policy prescription, 45 percent of world production would be carbon-free in the year 2100.

The DICE climate model and economic model are relatively unremarkable (although the choice of discount rate – the value that we place on costs and benefits in the future – and the assumed pace of economy-wide technological advancement have powerful impacts that dominate the model's policy recommendations). The basic structure of DICE is flexible and can accommodate a wide assortment of assumptions about damage and abatement costs. These feed-back mechanisms are also the most conjectural parts of the model: Who can know with any certainty what economic impacts will transpire at 1°, 2°, or 3° increase in global mean temperature, or 50, 100, or 150 years in the future? How can we predict with any accuracy the costs of technology not yet invented? Yet these judgments are all-important to the model: as described in the following sections, DICE is extremely sensitive to small changes to the set of assumptions that make up its damage and abatement functions.

##### **Costs of Allowing Climate Change to Continue**

In DICE, damage costs as a share of gross world output grow in proportion to the square of increases in global mean temperature (relative to 1900). The damage function's parameter and exponent are cited as having been set with the goal of matching as closely as possible Nordhaus' two point estimates of damages from climate change: at 2.5°, 2 percent, and at 6°, 11 percent of gross world output. The damage costs for a 1° increase from 1900 implied by this function are 0.3 percent of gross world output.

The 2.5° damage costs on which the DICE damage function is based are the sum of six categories of non-catastrophic climate change damage and an additional estimate for catastrophic damage. These include three kinds of market impacts: agriculture, other vulnerable markets, and damage to coastal property from rising sea-level. Damage costs also include monetary values for three categories of non-market impacts: lives lost to climate change, the pleasure derived from living in a warmer climate, and damage to human settlements and natural ecosystems. Similar explanations of the damage costs assumed for catastrophic impacts at 2.5° and for both non-catastrophic and catastrophic impacts at 6° are not included in the DICE materials.

Revising the DICE damage function to approximate Richard Tol's (2002) higher estimated damage costs of 2.7 percent of world product at 1.7° increase since 1900 (maintaining the rate of increase) results in an impressive change to the model recommendations: an initial SCC of \$59/tC and an abatement path that reaches zero industrial emissions in 2145.

### **Costs of Stopping or Slowing Climate Change**

The DICE abatement cost function makes the strange assumption that the price of carbon-less technologies will decline over time regardless of the amount of investment in abatement. The costs as a share of gross world output of abating greenhouse gas emissions are the "backstop" costs (the extra cost of using carbon-emission-less technology) weighted by a rapidly increasing function of the emissions control rate: this formula results in marginal costs rising as the control rate rises (and the easiest and cheapest abatement strategies are exhausted) and average costs falling autonomously over time. Backstop costs are a function of the CO<sub>2</sub>-equivalent-emissions output ratio (or carbon intensity) which decreases autonomously over time, and an assumed decline rate in the cost of the backstop technology over time. The initial cost of abatement for a 100 percent emissions control rate is assumed to be 5.2 percent of world product.

Making backstop costs a function of cumulative abatement costs, assuming a 15 percent return from learning by doing to a doubling of cumulative abatement costs (in keeping with recent literature), can be achieved with a small change to the abatement cost function. The use of this revised abatement function results in no change in the initial SCC but a much more rapid path to total abatement than in the DICE recommendations, reaching zero industrial emissions in 2175. Alternatively, making the assumption that just 8 percent of carbon emissions can never be eliminated is enough to keep temperatures from dropping in centuries to come. Thus the long-run behavior of DICE also depends on unobservable features of the abatement and damage cost functions.

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## V. Reflecting Costs and Benefits in Energy and Climate Policy Analysis

The proper characterization of technology and its performance over time are critical elements in the assessment of proposed energy and climate policies. Even a cursory review of past policy studies suggests, however, that most analysts focus on a limited set of costs and an even smaller set of benefits in their assessments. The result all too often is a biased set of studies that tend to reinforce the status quo, inadequately inform policy-makers about new market potential, and serve to constrain the development of innovative policies.

In examining the more complete literature on the costs and benefits of energy technology investments, there are at least four categories of costs which might be incorporated into future energy and environmental policy assessments: (1) Direct Investment Costs; (2) Operating and Maintenance Costs; (3) R&D and Program Costs; and (4) Transaction and Search Costs.

But there are also at least four categories of benefits which should be similarly reflected in future assessments: (1) Direct Savings from Lower Compliance Costs; (2) Process Efficiency and Other Productivity Gains; (3) Environmental Benefits not Captured within normal Market Transactions; and (4) Spillovers and/or learning created/induced by either the technology investment, or the R&D efforts.

The table below summarizes the list of costs benefits from both a market and non-market perspective. Within the market perspective the benefits and costs are further identified as impacts which are typically or often accounted in a given policy assessment and those which are typically overlooked or unaccounted in the analysis. The non-market perspective—essentially reflecting impacts beyond the consideration of “normal market transactions”—is more often overlooked in such assessments.

	<b>Costs</b>	<b>Benefits</b>
<b>Market Perspective</b>	<b>Accounted:</b> Investments, O&M expenditures	<b>Accounted:</b> Energy bill savings and lower compliance costs
	<b>Unaccounted:</b> Transactions and search costs	<b>Unaccounted:</b> Non-energy benefits
<b>Non-Market Perspective</b>	Program and R&D expenditures, environmental and health impacts	Spillover, learning, economies of scale and scope

**Table 1. Costs and Benefits from a Market and Non-Market Perspective**

Given the significant role of energy use in almost all policy studies there is generally some treatment of both price and quantity impacts of identified policies. But there may be even larger non-energy benefits which amplify the return on a given energy-related investments. These can play a significant role in both a microeconomic and a macroeconomic perspective. For example, if firms or consumers realize there may be other benefits associated with the adoption of a technology, they may be more likely to adopt or invest in it. Hence, from a microeconomic perspective, the decision to adopt is greatly influenced by an improved technology characterization. Once adopted, the greater productivity gains associated with the decision to adopt can also have an important macroeconomic impact. Worrell et al (2003) suggest that these non-energy or productivity-enhancing benefits often may be significantly larger than associated energy bill savings associated with energy efficiency improvements. Table 2 summarizes these non-energy benefits.

<b>Waste</b>	<b>Emissions</b>	<b>Maintenance and Operating</b>
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO <sub>2</sub> , NO <sub>x</sub> , SO <sub>x</sub> emissions	Lowered cooling requirements
Reduced waste water		Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/machinery
Materials reduction		Reductions in labor requirements
<b>Production</b>	<b>Working Environment</b>	<b>Other</b>
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased Reliability in Production	Improved air quality	Improved worker morale

**Table 2. Non-Energy Benefits From Efficiency Improvements**

Source: Finman and Laitner (2001).

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# INNOVATION POLICIES AND SOCIAL DYNAMICS

## VI. Renewables Investment: Tens of Billions Needed Now for “The Greatest Generation”

The generation that overcame the Depression and WWII is often called “The Greatest Generation”. But today’s young people face an equally heroic task: overseeing the rapid transition to a clean energy future that can stabilize the global climate. To hold global warming to the manageable, low end, in the decades from 2020-2050, today’s young people will have to rewire the entire planet with new energy technologies, creating millions of jobs, and cutting emissions of global warming pollution 20% or more every ten years.

Climate policy discussion is generally focused on the need for legislation capping global warming pollution in the near term, and then requiring steep reductions by mid-century. The first task, stabilizing emissions over the next few years, can be done using known technologies at relatively low cost. But subsequent deep and rapid cuts will require a whole suite of commercial clean energy solutions—for example, solar cells, solar thermal power, fuel cells, battery and other storage technologies, biofuels from cellulosic and other non-food crops, high altitude wind, tidal power, geothermal power. These technologies are currently not cost competitive beyond small market niches.

These new energy technologies will require two decades or more of intensive development to move from early design phases to a broad competitive position in the marketplace. This means that today’s rising “Greatest Generation” needs investment of over \$10 billion per year—beginning now—to enable them to do the job they will need to do for their kids, our grandkids. Climate policy thus requires two complementary actions: **stabilize and invest**. Legislation can require stabilization and then cuts, but annual investment of tens of billions must also be made in the technologies which will, in fact, allow those cuts.

This briefing paper reviews the case of wind power to illustrate (1) how new technologies can achieve rapid commercialization, providing a new base for economic growth and employment, and also (2) to suggest the magnitude of investment across the spectrum of solutions that will be required today to enable domestic cuts of 80% by 2050.

### **The Wind Power Story**

During the late 1970’s, fearing US oil dependence on the Middle East, the US government provided substantial subsidies to alternative energy production, and the state of California upped the ante with their own incentives. Investors rushed into solar and wind. While poorly designed in some respects, the policy overall was a tremendous success, especially for wind. Wind prices fell rapidly: from \$.25 per kWh in 1980, to \$.05 in 1995. In the early 1990’s, California was the world’s leader in both installed wind capacity and wind power jobs.

However, when US policy-makers lost interest and subsidies disappeared, the industry shifted to Europe, and Denmark and Germany are now the global leaders in wind energy technology and employment. In 2007, with global capacity now close to 80,000 MW, in a good site and with access to transmission lines, wind power is one of the cheapest electricity source in the world, and it is the second fastest growing source of new power in the world, after solar.

Wind power illustrates an extraordinary success story in US government promotion of clean technology, and it suggests a promising avenue—indeed, the key avenue-- for a way through the climate crisis. The first lesson from wind, consistent with a host of other examples, is that it takes a couple of decades to move new energy

technologies from the design stage to commercialization. Regarding costs, over the past twenty-five year period of significant, but declining, government support, the global subsidies that were required to push wind power to a competitive, commercial technology were on the order of \$4–\$8 billion in total.

Today's young people need comparable scaled investment in a diverse suite of a dozen or more technologies. The wind power example, and a series of industry needs assessments, suggest that over the next decade, annual global, government investment in the tens of billions will be required to drive down the costs of clean energy. This is ten to twenty times current government expenditures, but also equivalent to just a few weeks of spending on the war in Iraq and Afghanistan.

Market failure explains the need for large scale public investment. As computers and cell phones demonstrate, the market works wonders diffusing profitable technologies. And venture capital is flowing to clean energy: approximately \$2.5 billion was invested in start-ups last year. But this sum falls far short of the amount needed to drive a dozen technologies to rapid commercialization.

There are two reasons for this. Market actors face the short term demands of the stock market; in the US, very few companies can make large investments that have paybacks of longer than five years. In addition, the kind of fundamental R&D that is needed has broad public benefits, so that any company who did invest in revolutionary new technology, would never capture all the returns. So the incentives are just not there for sufficient early investment from the private sector. From jet planes to the internet, government support for innovative new technologies has played a decisive early role. As the technologies mature and become profitable, then we can count on capitalism to do what it does best: spread the clean energy revolution rapidly across the planet.

Stabilize and invest. These are the two policies that we must put in place now to enable today's young people to rise to the challenge they will face as the new, greatest generation. The very good news is that both of these goals are affordable. With respect to investment, we can provide the clean energy tools our children will need for global basic annual RD&D expenditures in the tens of billions of dollars.

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## VII. The Energy Efficiency Technology Resource

Compared to the year 1970, changes in technology and market structure accelerated the rate of decline in the nation's energy intensity. In 1970 our economy used about 18,000 British thermal units (Btus) of total energy for every dollar of value-added produced in the United States. Today we use less than 9,000 Btus. Broadly speaking, energy efficiency technologies now provide 75 percent of all U.S. demands for energy services compared to the 1970 pattern of energy use (Laitner 2006). Despite the significant contributions from these past energy efficiency gains, however, there is a tendency in economic models and conventional policy analyses to assume that any new energy efficiency investments will make only a limited contribution to our nation's energy future. And even when such improvements are thought actually to be possible, the standard logic suggests that any further energy efficiency gains are not likely to be "cost-effective."

The operative assumption of this particular mindset is that we've pushed the efficiency frontier as far and as fast as it can reasonably go. The good news, however, is that the evidence points to a very real prospect for new and substantially greater gains in energy efficiency—especially when one explores the role of government and industry as both innovator and champion of new and more productive energy technologies. The evidence suggests, moreover, that energy efficiency improvements do not have to be about ratcheting down the economy. Instead, they can be all about providing new services, making new products, and providing new ways to both work and play. Some analysts believe, in fact, that increased energy efficiency may be critical to a long-term sustainable development path.

Despite the impressive efficiency gains following the oil crises in the 1970s and early 1980s, energy efficiency resources still remain an impressive investment opportunity (McKinsey 2007, Eldridge et al. 2007, Lovins 2006, Elliott et al. 2006, Shipley and Elliott 2006, Laitner 2006, and Laitner 2004).

A preliminary assessment by the American Council for an Energy-Efficient Economy (ACEEE) shows that Americans now invest about \$200 billion in energy-efficient technologies each year. This compares to about \$100 billion annually for on-going conventional energy infrastructure and \$2 trillion in total investment for all purposes. While definitive estimates are premature, we scaled up our current research findings to project the impacts of accelerated market transformation through rapidly increased efficiency investment. In simple terms our findings about current investment levels assume a typical payback of about two years. In other words, in the absence of strong policy or other social incentive or motivation, businesses and consumers are unlikely to adopt a new technology unless it has roughly a 50 percent return on investment (i.e., the inverse of a two-year payback).

Assuming that policies, market forces, and new financing mechanisms facilitate substantial movement "up the cost curve" so that consumers and businesses are willing to accept longer-payback periods, we can posit a future in which businesses and consumers invest based on an average five-year payback. In that scenario, *annual investment in energy efficient technology would become a \$400 billion market*. If the United States were to follow that course—and other ACEEE studies show this can be a cost-effective policy path—U.S. energy consumption in 2030 would not exceed the current forecast for 2013. And we can do better than that over the long haul.

There are a large number of existing technologies that can be tapped to improve overall energy productivity. For instance, there are near-term and highly cost-effective upgrades that might improve the new car fuel economy from 27.5 miles per gallon today to 40 miles or more per gallon by 2030. When spread throughout the full fleet of existing light duty vehicles, this single measure might reduce total transportation fuels by 20 percent

or more by 2030. These efficiency gains mean comparable reductions in air and water pollutants as well as greenhouse gas emissions—all at a net savings to consumers, businesses, and the economy.

Additionally, there are productivity gains to be made in our nation's buildings and industries. Recent estimates by the Oak Ridge National Laboratory (ORNL) and the U.S. Environmental Protection Agency's (EPA) Energy Star program, for example, suggest that energy and greenhouse gas emissions can be reduced by 30 percent or more with existing technologies. The savings can be provided in a way that, on net, saves even more money. Yet another study by the Lawrence Berkeley National Laboratory (LBNL) indicates that converting the energy is now wasted in our nation's industries and electric utilities might become still another source of supplemental heat and power for use elsewhere in the regional economy. In effect, the energy we now waste in the mining, refining and processing of fossil fuels, as well as in the generation of electricity, could become a source of both supplemental heat and electricity for use in our nation's industries and buildings. LBNL suggests an economic potential to provide as much as 20 percent of our nation's current electricity requirements using "waste-to-energy" technologies.

While our preliminary assessment indicates the efficiency market is already large, the more important question is how large the market can ultimately be, and how rapidly it can be developed. A new study organized by the United Nations Foundation, pulling on the expertise of some two dozen international energy experts, called energy efficiency both the largest and least expensive energy resource. The study suggested that the G-8 and other nations could double historical rates of efficiency improvement through at least 2030. The new report by McKinsey Global Insight (2007) indicated that North America could meet all future growth in energy service demands through cost-effective efficiency investments. This means that the economy would grow at current forecast rates, but that energy demand growth would flatten out.

The most hopeful observation we take from this and other research is that, because it has been invisible to many investors, efficiency may well be the sleeping giant of the clean technology spectrum. If we can craft the new financing approaches and policies needed to tap efficiency opportunities at a faster pace, we can create vibrant new markets as we make measurable progress on our energy and environmental challenges. We can also make efficiency one of the most effective resources in managing energy-related risks, as its diverse and dispersed nature cut across all areas of the economy. The core question that remains to be answered is: How do we further develop energy efficiency related investment mechanisms to capitalize on the full investment potential of the energy efficiency market? Participants in the E<sup>3</sup> Network are invited to join with us in seeking answers.

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## VIII. Changing Human Behavior to Reduce Climate Change: Moving Beyond the Techno-Economic Model

Current concern over global climate change stems, in part, from the predominant evidence that its causes are anthropogenic: the result of human behavior. What is less widely recognized is that the solutions are also rooted in human behavior. Instead, the first and most common response from the public and policymakers alike is to look to *technology* to provide the answers. And, when available technologies aren't adopted, we look to the field of *economics* to explain why not. This simplistic "techno-economic" approach is insufficient for solving complex environmental problems that are rooted in equally complex social structures and that involve multi-dimensional behavioral elements that extend beyond the realm of economics. Effective solutions must draw on a broader understanding of social systems and human behavior. This knowledge, when used in conjunction with economic insights, can help by: 1) ensuring the development of *appropriate* technologies, 2) increasing the adoption of existing technologies, 3) improving the effectiveness of economic policies and forecasts, and 4) identifying non-economic mechanisms for catalyzing the types of social change required to reduce CO<sub>2</sub> emissions and moderate climate change. Therefore, the question that economists must ask is: ***How can a more holistic understanding of the drivers of human behavior inform global climate change models and policy?***

### The Techno-Economic Model

Since 1970, energy efficiency has met three quarters of the increase in energy service demand in the U.S. These efficiency gains resulted from a broad array of efforts undertaken in response to the energy crisis of the 70s and included the development of specific theoretical models of energy-related behavior. Some of these same models are currently being applied to climate change policy. Two of the primary models include the engineering model and the economic model of energy efficiency. The engineering model addresses the issue of efficiency primarily in terms of the development of energy-efficient equipment and technology, while the economic framework focuses on the response of rational decision makers confronted with changes in energy prices within a market setting.

Although engineering research has been successful in developing models of the potential energy savings of given technologies, it has been less successful at explaining the huge variations in actual energy use and savings due to its inability to address the human dimensions associated with technology dissemination and use. The economic perspective, based on the assumption of rational economic behavior at given energy prices, has succeeded in addressing some of the weakness in the engineering model. The economic research seeks to explain energy-conservation or energy-efficient behaviors largely as a function of rational choices made by individuals given different levels of income and energy prices. This approach assumes that firms and individuals weigh the costs and benefits associated with adopting certain energy-consuming behaviors and that they choose to perform these behaviors when they are found to be economically advantageous. Moreover, the model suggests that the prevalence of energy-efficient behaviors may be enhanced through the introduction of carefully crafted economic incentives and disincentives (Archer et al. 1987).

Taken together, these two approaches provide a techno-economic perspective that suggests a logical and linear framework of technical diffusion in which the technical expert defines the solution through a process of research and demonstration and the consumer adopts it and applies it when it is in his or her economic interest to do so (Parnell and Popovic Larsen 2005). According to the techno-economic model, the primary barriers to the transfer of energy-efficient technology are 1) the lack of more efficient technologies, 2) the lack of sufficient economic incentives, and/or 3) the lack of timely, sufficient, or even accurate and complete information. To date, most energy research and policy aimed at increasing energy-efficiency has been rooted in a techno-economic model (Parnell and Popovic Larsen 2005). A cursory evaluation suggests that although these policies have achieved some success, their success has been limited due to the narrow focus of the techno-economic model and the flawed assumptions on which it is based.

### The Contribution of Social Science to Understanding Energy Consumption and Conservation

The contributions of social scientists to an understanding of energy-related behaviors are multifold. One of the most comprehensive studies of the subject was developed by Stern and Aronson in 1984. Their study reveals the complex ways in which energy is both essential to our everyday lives and yet often invisible to its users. Since the turn of the 20<sup>th</sup> century, as a society we have dramatically shifted our fuel use patterns in terms of the type and quantity of fuel used. For example, in terms of home heating we have gone from chopping wood, to shoveling coal, to purchasing fuel oil, to the almost effortless use of natural gas and electric furnaces. In the

process of this transition, our active involvement in the process of heating our homes and our visual appreciation of the volume of our fuel consumption have been diminished to the point that energy consumption has largely become invisible and the only remaining visible aspect of energy that remains is the monthly bill (Stern and Aronson 1984). At the same time, there has been tremendous growth in the energy services on which we rely, including air conditioning, heating, cooking, lighting, computing, television, and the whole assortment of new electronic gadgets available today. The resulting paradox is one in which energy is both more and more integral to our lives and our lifestyles, while it is less and less visible in our everyday lives.

The historical context provides a framework for understanding current behavior patterns. A social science perspective uses this perspective as one piece of a holistic approach that looks beyond the economic conception of people as rational, economic actors and instead recognizes that individuals are both overtly and subconsciously influenced by a variety of non-economic variables including their values, beliefs, and attitudes, as well as prevailing social norms, group norms and interpersonal dynamics. For example, in a recent study of hotel guest behaviors, Cialdini sought to increase the number of guests that were willing to reuse their towels instead of having them laundered on a daily basis. The study left cards in each hotel room asking guests to reuse their towels and noted that 75% of people staying in the hotel had, at some point in their stay, reused their towels. By emphasizing the behavior as normative, Cialdini was able to lift reuse rates from 35% to 58%, saving both water and energy (Cialdini 2005). In another study, Schultz et al. (2007) used a social norms approach to help homeowners to conserve energy. The study involved delivering notices to household doorsteps, telling homeowners how their energy consumption compared to the neighborhood average. Homeowners who were consuming more electricity than their neighbors reduced their consumption.

In addition to the influence of social norms, social scientists have explored a variety of other topics, including: 1) the ways in which different types of consumer feedback and information affect energy consumption; 2) the effect of non-economic incentives and disincentives; 3) the impact of social marketing campaigns; 4) the importance of social networks and social movements in shaping energy demand and technology adoption; 5) the effect of group contingencies and behavioral modeling on individual behavior; 6) the significance of commitment to behavioral change; 7) the importance of the social and political context in shaping individual attitudes and behavior, 8) the relationship between social status, values and energy consumption; and 9) socio-cultural patterns of energy consumption.

Social scientific research has succeeded in identifying and measuring some of the important social dimensions of energy use and conservation that are not captured by the techno-economic model and in suggesting alternative frameworks that provide a more realistic and accurate picture of the relationship between energy consumption, information, incentives and disincentives, and a variety of social influences and structures that channel human behavior. Additional work is needed to assess the breadth and nuances of the research that has been completed, as well as to identify knowledge gaps and promising areas of future research. Only through a more comprehensive understanding of the non-economic variables that shape social preferences will it be possible to effectively catalyze the level of social change required to reduce energy consumption and forestall global climate change.

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## IX. Climate Change in the Context of Peak Oil

In thinking about the economics of climate change, I believe several important aspects and alternatives are omitted from many discussions. These are: peak oil, transportation alternatives, globalization and relocalization or eco-localism.

The first of these is peak oil and peak natural gas, or the imminent onset of depletion of these fossil fuels (within the next 10-20 years). The omission of the issue of the physical supply of these fuels is significant for two major reasons. First, the higher fuel prices resulting from the peaking of petroleum and natural gas will have major impacts on the economy (e.g., recession) and on equity aspects of fuel distribution and use. [Note: as observed by Richard Heinberg, some in the climate change activist community dismiss this issue via their acceptance of overly optimistic official estimates of petroleum and natural gas reserves.] Second, many of the mainstream solutions to peak oil involve the development of fuel substitutes (e.g. coal to liquid) that will require massive investments and will produce increased levels of greenhouse gas emissions. Aside from increasing fuel efficiency of vehicles, the Hirsch report on peak oil sees coal to liquid, oil shale, tar sands and enhanced petroleum recovery as the only solutions to the liquid fuel problem of peak oil. This conventional discussion of peak oil—often in the context of reducing dependence on (foreign) oil—has already created a stampede for coal to liquid subsidies. [New York Times, May 29, 2007] Large capital investments in coal to liquid technology might both increase greenhouse gas emissions and reduce funds available for investment in ways that would reduce emissions.

The key operating assumption in the conventional peak oil analysis is that American drivers of cars and trucks should be able to drive as many miles as they do currently, though perhaps in a more efficient vehicle. This approach to peak oil closes off alternatives important for climate change. These include: (1) fuel switching to renewable fuels with a) good energy return on energy invested (possibly including electric vehicles) and b) lower greenhouse gas emissions and (2) mass public transportation and rail freight. We need to make sure that both fuel switching and mode switching (car to bus, truck to train and air to train) are part of the discussion, particularly when it comes to issues of subsidies. There are clear equity issues re funding of mass transportation.

Further, we need to talk about ways to reduce the necessary amount of miles traveled—both for people and freight. This component of the discussion has two parts: globalization and relocalization. It seems increasingly likely that the dual impacts of global warming and peak oil will undermine the profitability and logic of the long-distance trade (i.e., trans-oceanic exploitation of cheap labor). First, increasing oil prices due to peak oil will increase transportation costs. Fuel prices may also increase as a result of global warming policies such as taxes on the carbon intensity of fuel. This would impact aviation (passenger and freight) particularly hard and would also have an impact on ocean freight transportation. More significantly, the impact of global warming will likely erode or damage transportation infrastructure due to both increased heat events and rising sea level. Further, it will likely reduce engine efficiency (of trains, trucks and planes). These impacts—and others—will undermine the low cost and easy availability of goods produced at long distance; both manufactured and agricultural goods would be impacted. [Think of Wal-mart's greenhouse gas emissions from transportation.] It is also often noted in the environmental literature on globalization that manufacturing production has been relocated to areas with worse energy efficiency and higher greenhouse gas emissions. Thus, increased globalization increases greenhouse gas emissions and global warming and peak oil undermine globalization. This has implications for trade treaties designed to increase long distance trade.

The need to reduce the consumption of miles traveled (for peak oil or greenhouse gas emissions reasons) has led to the growth of a relocalization movement. This response (primarily to peak oil) has two major directions,

partly depending on the agency of the response. When the response comes from city or regional institutions (e.g., Hamilton, Ontario or Portland, Oregon), it is a modified form of city planning with more or less conventional approaches and growth goals, now including either global warming goals or peak oil constraints. When the agency is a local group or non-governmental organization, it is much different approach—one which sometimes focuses on building alternative, community economies. In this case, the relocalization approach is much closer to what I have called eco-localism. In addition to focusing on reducing the amount of transportation consumed (hence less petroleum used and fewer greenhouse gas emissions), these relocalizers also define goals other than individualized consumption and focus on other shared or low emission activities, such as sustainable agriculture and co-housing. They thus address the consumption side of greenhouse gas emissions in several ways. [While there are left critiques of such eco-local community economies, they are being consciously developed in response to peak oil and global warming and should not be ignored.

Finally, it seems to me that alternative technologies and effective policies designed to ensure their implementation are unlikely to reduce greenhouse gas emissions sufficiently to avoid overshooting the 2° goal for temperature increase. This conclusion—along with the impending reality of peak oil—means that we will need to consider ways to reduce the consumption heating, electricity and transportation. This will require focusing on the quality of life or well being rather than upholding our material standard of living or “the American way of life”. The Center for a New American Dream in the US and the New Economics Foundation in the UK have begun to do some interesting work on this.

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## CAP-AND-AUCTION

### X. Who Gets the Money? Distributional Implications of Carbon Revenue Recycling

Sooner or later the United States will join the other nations of the world in instituting policies to curb CO<sub>2</sub> emissions. One way to do so is to raise the price of fossil fuels by levying charges based on their carbon content—in effect, making users pay for access to the limited carbon reabsorption capacities of the biosphere.

The carbon charge can be thought of as a user fee. It could take the form of a fixed price (analogous to a tax) per unit carbon, or a fixed number of permits that entitle the holder to introduce a specific amount of carbon in a given year (totaling to a national cap on emissions), with the permits auctioned and their price set by the market. In either case, the easiest way to collect the money would be via an ‘upstream’ system, implemented at the point where the carbon enters the economy – such as tanker ports, pipelines, and mineheads (Repetto 2007). The Congressional Budget Office (2001: 6) reports that there would be roughly 2000 such collection points in the country.

Carbon charges will mean a lot of money. How much depends on how high the charge is set (or equivalently, how low the carbon-emission cap is set) and on the price elasticity of demand for carbon. Based on the US emissions target in the Kyoto Protocol and ‘middle-range’ assumptions on the price elasticity, Barnes and Breslow (2003: 143) calculate that carbon charges would yield roughly \$240 billion annually (in 1999 dollars) in 2010. Because demand for fossil fuels is price-inelastic, a more ambitious cap—like the 50% emissions reduction by the year 2050 proposed by the Europeans —would generate even larger revenues.

This prospect raises the question: Who gets the money?

The net distributional impact of carbon charges depends on (i) the incidence of the charges themselves and (ii) how the resulting revenue is recycled into the economy. In the US, the incidence of carbon charges would be regressive: as a percentage of income, the resulting price increases would hit the poor harder than the rich. Yet in absolute terms the rich would pay more, as shown in the “cost” column of the following table:

Income Decile	Mean Household Income (\$)	Costs from Higher Prices (\$)	Benefits from Recycling (\$)	Net Effect (\$)	Net Effect as % of Income
1	6,884	1,158	1,512	+354	+5.1%
2	13,127	1,418	1,777	+359	+2.7%
3	20,453	1,800	2,034	+234	+1.1%
4	28,107	2,085	2,358	+272	+1.0%
5	35,900	2,089	2,393	+304	+0.8%
6	44,406	2,303	2,429	+126	+0.3%
7	53,613	2,719	2,549	-170	-0.3%
8	66,179	2,800	2,902	+102	+0.2%
9	87,480	3,144	2,916	-228	-0.3%
10	161,801	4,119	2,740	-1,378	-0.9%

Source: Barnes and Breslow (2003: 144) based on “middle-range” scenario. Units are 1999 dollars.

**Table 1: Distributional Incidence of Carbon Charges and Equal Per Capita Revenue Recycling**

If carbon revenues are recycled on an equal per capita basis, the net impact is progressive. (Equal per capita payouts are shown in the “benefits” column of the table; differences across deciles are due to variations in household size.) In purely pocketbook terms—without counting the environmental benefits of curbing fossil fuel emissions—low-income households would be net “winners” while upper-income households would be net “losers.”

The last column in the table depicts the net effect: the richest decile incurs a net cost equivalent to 0.9% of household income; the poorest decile reaps a net benefit equivalent to 5.1% of household income. A doubling of total carbon revenue (as a result of tighter caps or a lower price elasticity of demand) would double these net effects.

These numbers are rough estimates, but other studies have produced similar results (for example, CBO 2000, 2001). The numbers could be further refined among other ways by allowing price elasticities of demand to vary across deciles and by including impacts on the producer side of fossil-fuel markets. If carbon charges are partly absorbed by reduced profit margins—rather than passed 100% to consumers as assumed in most calculations—the net distributional impact would be more strongly progressive, given that corporate stock ownership is more unequal than income distribution.

One way to recycle carbon revenues on an equal per capita basis is via a “sky trust” that makes payments to every woman, man, and child in the country—an arrangement analogous to the Alaska Permanent Fund’s annual dividends from oil-extraction revenues. Alternatively, part or all of the carbon revenues could be recycled via provision of public goods such as national health care. If these public goods benefit all persons equally, the net distributional impact is the same. (Another option is tax shifting, for example using carbon taxes to replace payroll taxes as advocated by Al Gore (2006). This, too, would yield an overall progressive net impact, but it would fail to benefit non-workers including the old, the young, the disabled, and the unemployed; moreover, it would tie the future of Social Security to what ultimately will be a diminishing revenue source.) To offset employment impacts in carbon-intensive sectors (like coal mining and trucking), some fraction of the revenues must also be earmarked for transitional adjustment assistance.

Politically, an egalitarian answer to the question of “Who gets the money?” is appealing for two reasons. First, due to skewed income distribution, the winners would outnumber the losers: as the table indicates, roughly 70% of the people end up with more money in their pockets. Public attitudes to higher prices at the gas pump could be transformed radically if consumers knew that the extra money was going to them, rather than to oil companies or the government.

Second, the egalitarian distribution of revenues—and the newly created property rights that underlie these revenues—would affirm the ethical principle that the gifts of creation are held in common and equally by all. People vote their values, as well as their interests. An egalitarian answer would reflect moral values that are deeply held and widely shared.

By framing a policy that is grounded in interests and values supportive of both environmental protection and the egalitarian distribution of carbon revenues, we can help to ensure that the US moves sooner, rather than later, to curb CO<sub>2</sub> emissions.

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## **XI. Arguments for Auctioning Carbon Permits**

In discussions over how best to implement mandatory restrictions on carbon, the most commonly discussed option is a cap and trade system. One critical economic question surrounding cap and trade is how to distribute the permits, which represent a limited right to emit carbon. The two main competing mechanisms are free allocations to polluters (usually based on past emissions levels, output levels, or carbon intensity), often called “grandfathering” or to sell the permits (usually through an auction of some type). The economic answer to this question is clear and unambiguous: permits should be auctioned.

### **1. Price Equivalence**

Restricting carbon emissions will raise energy prices. As a byproduct of fossil-based energy consumption, restricting emissions will either require energy producers to produce less energy, or to undertake some type of costly action to abate their emissions. These two general types of effects will reduce the amount of energy producers will be willing to sell at any given price or, equivalently, raise the price for which they sell any given quantity of energy. Market mechanisms, such as carbon taxes or cap and trade systems, are generally preferred because they are widely believed to be the least costly method of achieving a given level of reduction. What is important to note is that carbon taxes and cap and trade systems both put a price on emissions and the impact of any given level of carbon price (via a tax or a permit) is the same no matter how it is implemented. I.e. a carbon tax, cap and trade with grandfathered permits, and cap and trade with auctioning will all impose the same energy price impact for any given level of emission reduction.

There appears to be much misunderstanding about the implications of grandfathering vs auctioning permits, with many claiming that grandfathering or other free allocation systems will not have the same impacts on energy prices as auctioning. This is incorrect. Imagine the following situation: Last year, the U.S. emitted 100 tons of CO<sub>2</sub>, and this year, it will restrict its emissions to 90 tons via a cap and trade system. There appears to be no disagreement that selling the permits to emitters will cause energy prices to rise: As the price of production rises, producers will pass some or all of those increased costs onto their customers. To see that this is identically true under free allocations, assume that the permits are allocated for free, and consider the decision that must be made by a producer who did not receive enough free permits to cover all of the pollution he or she would have otherwise emitted. She must either: 1) Buy a permit from another polluter in the secondary market; 2) Undertake costly abatement activity (e.g. increasing conversion efficiency at an electricity plant). Under either option, her costs per unit will rise. If she is going to sell the units she produced without losing money, she will have to raise the price of her output. Because prices are set at the margin, i.e. the price of the last unit sold in a market is the price that all units sold receive, the price of all output from all producers will increase by the same amount. The result is that the even those producers who received free permit allocations will price their output exactly as if they had to pay for the permits.

A third option for our unlucky producer is to cut output. If she believes that she can not increase her selling price enough to cover the cost so of either option 1 or 2 above, then she will have to cut output to reduce her pollution enough to fit under the cap. Like any other reduction in supply, this will cause prices to rise. Again, because all units will sell for the same price, this price increase will accrue to units sold with the benefit of free allocations. In all three cases, producers who receive free permits will price their output exactly as if they had received no free permits.

### **2. Opportunity Cost**

Because energy is a critical input to economic activity, increased energy prices will tend to slow economic growth. Given that the immediate impact on energy prices and the initial direct impact on economic growth of a cap and trade system is identical regardless of how the permits are distributed, the economic question is now

the ultimate disposition of the burden of the price increase, and how much of the reduction in economic growth can be ameliorated.

Under grandfathering, polluters receive a lump-sum distribution of valuable assets. This represents a pure lump-sum wealth transfer from energy consumers to energy producers. There is no incentive attached to this transfer, and thus produces little or no change in marginal behavior; i.e. it neither increases nor decreases the incentives for economic activity. The direct cost of the cap and trade system via increased energy prices will be the whole economic story.<sup>5</sup>

With auctioning, however, the government will collect the revenues and can put them to economically productive use. Here, the term “economically productive” means a use that changes the marginal incentives for economic activity. Two commonly cited examples are reducing existing taxes and investment in energy efficiency. Since taxes discourage economic behavior, reducing taxes increases economic behavior. A simple example is the payroll tax, or FICA, which is collected to fund Social Security and Medicare. Because it lowers the economic returns to working, it discourages some work on the margin. Because it increases the cost hiring, it also discourages employers from hiring. Though the magnitude of the effect is uncertain, there is no doubt that reducing the federal payroll tax would increase employment. Using permit auction revenues would thus increase employment and economic growth beyond what they would be under a grandfathered system. Whether or not the resulting increase in economic activity would be enough to offset the direct economic costs of the system is also uncertain.

Energy efficiency falls into a class of goods called “public goods” i.e. goods that can be consumed by more than person simultaneously. Markets tend to yield suboptimal investments in efficiency research and development. Using auction revenues to fund energy efficiency, or any other public good for that matter, would produce economic gains. The increase in energy prices would increase the economic return to energy efficiency, all else equal. Whether it would be more economically wise than reducing taxes or investing in other public goods is an open question.

It is important to note that it is equally possible for the government to put the money to unproductive uses. Over-investment in public goods is economically wasteful no matter what the source of revenue, and there is thus nothing automatically beneficial about auctioning as opposed to grandfathering. Lump-sum or per-capita redistribution of auction revenues is one such unproductive use. Since it only provides an incentive to be alive (for which there is already ample incentive) it does not encourage economic behavior that would not have occurred anyway. There may be other arguments in favor of such distributions or over-investments in public goods, but they are not based on increasing incentives for economic growth.

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<sup>5</sup> The long-run impacts on behavior can be significant and costly, however. Given the large sums of money at stake, grandfathering will tend to lead to rent-seeking behavior, e.g. lobbying by producers for a large share of the free allocation; and, depending on how the allocation system deals with new entrants, free allocations can result in more new polluting facilities (if not pollution) than would an equivalent auction-based system.

## XII. Global Warming, Jobs and Competitiveness

With global warming legislation live again in Congress, expect to see a new round of industry-sponsored studies predicting massive job-loss from efforts to cut global warming pollution. These will be updated versions from the late 1990's, which argued then that a Kyoto level cap would have lead to layoffs of up to 4 million Americans.

This prediction of a widespread jobs-environment trade-off is heard again and again, whenever new environmental policy is proposed. In fact, economists have carefully studied the jobs impacts of the last 40 years of environmental regulation, and have found no evidence of any significant jobs-environment trade-off.

Bottom line: Efforts to stabilize global warming emissions in the US over the next decade will stimulate job growth in clean energy and related sectors, and cause very few layoffs.

Here is a quick guide to analyzing and debunking industry claims:

### **Claim 1. Global warming stabilization will cost the economy millions of jobs.**

Industry-sponsored models generate big job losses using two tricks. One, assert that the regulation will lead to very high increases in energy prices. Two, run these increases through a model in which the economy is hyper-sensitive to energy prices. The result: regulation throws the economy into a recession, leading to job losses in the millions.

What we know: In the past, environmental regulation has never led to a macro-economic slowdown. In this case: (1) regulations will not lead to high energy price increases. A carbon dioxide price of \$30, phased in over several years, would gradually increase gas prices by about \$.30 per gallon, and gradually raise electricity prices on average by about 2 cents per KWh. Businesses regularly manage price changes of this size. Indeed, (2) the evidence is clear from the last couple of years that the modern US economy is not very sensitive even to very large and sudden energy price increases.

Result: There will be *no economy-wide impact* on jobs.

### **Claim 2. Global warming stabilization will lead to tens or hundreds of thousands of layoffs in affected industries.**

Again and again, predictions of layoffs in the hundreds of thousands have proven false. In 1990, for example, one industry analysis of the impacts of proposed acid rain and air toxics legislation stated that:

“a *minimum* of two hundred thousand (plus) jobs will be quickly lost, with plants closing in dozens of states. This number could easily exceed one million jobs-- even two million jobs...”

What we know: In spite of widespread predictions like this, the clean air law did pass in 1990. Between 1990 and 1997—a period of time in which SO<sub>2</sub> emissions were halved-- less than 7,000 workers in total were laid off as a direct result of the Clean Air Act Amendments. To put the figure in perspective, over that same period of time, *10 million* US workers were laid off for non-environmental reasons. Survey and other data confirm that, on average, about 2,000 workers nationwide each year lose their jobs because their plants face cost increases from environmental regulations. This is about 1/10 of 1 percent of all mass layoffs nationwide.

Much concern has focused on the impact of global warming caps on the auto industry. But as noted above, gas price increases of \$.30 per gallon phased in over several years will have minimal impact on the competitive position of US firms.

Result: For global warming legislation, expect direct layoffs in the low thousands annually. These will be concentrated in the coal industry. Policy needs to focus on adjustment assistance for coal miners.

**Claim 3. Global warming stabilization will lead to large energy price increases, causing industry to flee the US to countries like China not facing emission caps.**

What we know: Past episodes of environmental regulation have generated very little capital flight, among other reasons, because pollution control costs are a small share of operating costs. This is true as well for energy in most industries. Given differences in labor costs, firms already have large incentives to relocate; any industry that could move to the developing world will do so, regardless of small changes in energy prices. (China, of course, does not have reliable energy supplies).

Result: There will be very little industry relocation from global warming stabilization policy.

**Jobs for the Future.** In 2007, the Ford Motor company announced their intention to lay-off 30,000 American workers and cede the number two auto-maker slot in the US to Toyota—a company whose government has embraced Kyoto, and aggressively promoted fuel efficient vehicles. In the early 1990's Japanese firms understood how global warming was reshaping global energy markets, and they invested heavily in hybrid technology, and now they own that technology, and the jobs that come with it.

Global warming is becoming the driver of a global technology revolution, as today's college and high school students embrace the heroic task of rewiring the entire planet with a new generation of clean energy solutions. A policy framework that stabilizes and begins to cut global warming pollution here in the US will be needed to ensure that US entrepreneurs and businesses are at the forefront of that revolution-- creating the jobs of the future.

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# INTERNATIONAL COOPERATION

## XIII. Beyond Kyoto: Equity and Efficiency Reconsidered

### Statement of the Problem

One of the most significant political environmental debates involves the participation of developing countries in international climate control. At the heart of this controversy lies the preferential treatment afforded to developing countries by the Kyoto Protocol. Critics allege that the Kyoto Protocol prioritized equity at the expense of efficiency in international climate control, and as a result, failed to elicit the level of international cooperation necessary to prevent potentially catastrophic climate change. Implicit in this critique is an assumption, common within the mainstream of the economics profession, that equity and efficiency are conflicting aims. This assumption has falsely framed the debate over the participation of developing countries in international climate control as an either-or phenomena: either the Kyoto Protocol sacrifices efficiency in the pursuit of equity by exempting developing countries from mandatory emissions limits, or it improves efficiency by eliminating special exemptions for these countries.

As the international community embarks on the next round of climate negotiations, clarifying the tradeoffs between equity and efficiency is critical. Embedded in the design of the Kyoto Protocol is an allocation of property rights to the global atmospheric commons. The current Kyoto framework effectively awards developing countries unlimited property rights, on the basis of their limited ability to pay for reductions and their lesser contributions historically to the build-up of greenhouse gases in the atmosphere. However, developed countries, and in particular the U.S., are unlikely to agree to more extensive emissions reductions unless caps are placed on developing countries' emissions. In which case, the next stage in international climate negotiations will likely involve a very different initial allocation of property rights. If this is the future direction for climate negotiations, explicit acknowledgement of the distributional consequences of the initial allocation of emissions rights is crucial if the global community is to retain its current commitment to fairness for developing countries.

### Analysis

International cooperation is absolutely necessary to solve the problem of climate change. Emissions abatement is a global public good. This means that abatement in any one country benefits all other countries to the extent that it mitigates the threat of climate change. For this reason, all countries can benefit more from an internationally coordinated response to climate change than from a decentralized go-it-alone strategy. How much each country stands to gain from a coordinated response will depend on the distribution of the benefits and costs of the international agreement.

In thinking through alternatives to the current Kyoto framework, it's important to remember that *where* abatement takes place in the world is separable from the issue of *who* pays for it. Where abatement takes place is largely an efficiency issue. Who pays for abatement is a fairness issue. International climate control can be both fair and efficient, *if* the appropriate redistributive mechanisms are implemented.

The common criticism of the Kyoto Protocol is that it requires too little global emissions reduction to stave off climate change. Economists often reason that exempting developing countries from mandatory emissions caps is largely to blame. Absent mandatory caps, developing countries lack direct incentives to limit their emissions. Moreover, if developing countries offer lower cost options for reducing emissions than developed countries (a controversial assumption), the Kyoto Protocol is inefficient because it concentrates abatement in the developed world. Thus, mainstream economists are likely to conclude that 1) the benefits of U.S. participation in the Kyoto

Protocol do not outweigh the costs to the U.S.; and 2) improving the Kyoto Protocol requires capping developing country emissions and allowing for full-scale global emissions trading.

Though proponents of the Kyoto Protocol are often hesitant to portray it in this way, what the Kyoto Protocol effectively did was create property rights over the atmospheric commons in a way that favored developing countries. In essence, the Kyoto Protocol is an emissions trading scheme whereby the rights to emit at the levels specified by individual country quotas were awarded freely. However, unlike many emissions trading schemes, these rights are not fully transferable. The Kyoto Protocol limits emissions trading and the ability of developing countries to sell their rights through the Clean Development Mechanism. If indeed the Kyoto Protocol is as inefficient as many economists fear, the problems do not stem from the transfer of property rights to developing countries for equity reasons, but from the limited transferability of those rights once awarded. The Kyoto Protocol limits the sale of emissions rights from developing countries because developing countries have unlimited emissions rights and it is therefore difficult to gauge the additionality of their reductions beyond what would have occurred anyway.

In this next round of climate negotiations, the international community can impose limits on developing countries' emissions, while maintaining its commitment to fairness for developing countries, *if* mechanisms are used to shift the costs of abatement in developing countries onto developed countries. Limits could provide developing countries the direct incentives to mitigate greenhouse gases. Limits could also solve some of the additionality problems that currently limit the use of abatement options in developing countries. If international climate negotiations continue to favor market-based mechanisms like emissions trading to improve "efficiency", progressives should lobby for using those mechanisms deliberately to distribute the benefits and costs of climate control fairly. Using Kyoto's current framework, this means allocating quotas to developing countries in excess of current emissions levels. This would allow for continued emissions growth in developing countries, while providing those countries with a surplus of emissions rights to sell internationally. The ability to sell emissions rights provides incentives to mitigate emissions. Fairness, in this context, also means mandating more extensive reductions in developed countries, so there is 1) sufficient demand for the emissions rights developing countries have to sell and 2) enough mitigation globally to prevent catastrophic climate change.

Global emissions taxes offer a better alternative to the current Kyoto framework. A global emissions tax provides a more direct and transparent method of income redistribution, avoids the predictable shortfalls of imperfect markets for emissions credits, and adheres to the logic that the polluter pays. To maintain fairness for developing countries under a global emissions tax scheme, tax revenues would have to be recycled back to developing countries to offset the costs of their participation in global climate control.

Critics will argue that global emissions taxes with revenue recycling, or a global cap-and-trade system where developing countries are awarded the lion's share of emissions rights, will prove politically untenable in developed countries. However, the redistributive transfers implicit in the allocation of emissions caps under the existing Kyoto framework are no less objectionable and the Kyoto Protocol garnered the support of most of the international community.

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## XIV. Lessons from the Montreal Protocol for Climate Policy

It is both remarkable and disheartening that the example of the Montreal Protocol on Substances that Deplete the Ozone Layer has not played a more prominent role in the climate policy debate. The Montreal Protocol has been extremely successful in eliminating almost all production and consumption of ozone-depleting substances; it has achieved very close to universal participation by the nations of the world; and it has demonstrated the possibility of cooperation in funding and technology transfer between the rich and poor nations to achieve a global environmental objective. The Montreal Protocol was negotiated and implemented as a precautionary measure, before depletion of the ozone layer had reached crisis proportions. What lessons does Montreal offer for climate policy?

1. Large-scale economic models are not necessary to “predict” the costs and benefits of alternative regulatory strategies (including business as usual). In the run-up to Montreal, there were no economy-wide models in which the “ODS sector” was a key element, and estimates of the macroeconomic costs of regulation were not prominently featured in the discussion. Cost-benefit analysis did play a part, primarily in pointing out the very large economic losses associated with premature deaths and illnesses that would be caused by ozone layer depletion. However, the Montreal Protocol was viewed largely as the purchase of insurance against risks; the surprising discovery of the unexplained (at that time) Antarctic ozone hole was a key factor in bringing the initial negotiations to a successful resolution in 1987.

2. *Ex ante* estimates of the costs of regulation tend to be higher than *ex post* realizations, because of unexpected and unpredictable technological progress, and because of the cost-reducing effects of learning-by-doing and economies of scale. This pattern has been seen in other cases of environmental regulation (e.g., the SO<sub>2</sub> reductions under the amended Clean Air Act). In the case of Montreal, ODS replacement tended to stimulate productive R&D, led to redesign of some products and industrial processes, and generally gave rise to improved product quality (such as higher energy efficiency in many of the replacement technologies). The conventional “tradeoff” model of economics, in which environmental gains can only be obtained at an economic cost, did not predict the path of ODS replacement.

3. Leadership by the United States is essential. This is both a geopolitical and economic reality. Leadership has wider diplomatic benefits for the United States as well as being necessary for achievement of the underlying environmental objective. In the case of Montreal, the size of the U.S. market and the capacity of the United States to support innovation were important (although a great deal of the technological progress took place in other countries as well).

4. It is possible to negotiate regulatory regimes with “differentiated responsibilities” as to the timing of emissions reductions, assignment of emissions rights, funding of technology transfer, and structuring of decision-making procedures that can be agreed to by both developed and developing countries. In the case of Montreal, these took the form of the 10-year grace period and the establishment of the Multilateral Fund to cover “agreed incremental costs” of replacing ozone-depleting technologies in developing countries. Thus the dual requirements of full global participation and avoiding hindrance to the economic development of the poorer countries were satisfied. Efforts in this direction have been made in the Kyoto Protocol (through provision for Clean Development Mechanism credits, for example), but these have been hindered by design flaws and the non-participation of the United States.

5. Success is more likely if the regulation is not politically divisive domestically. In the case of Montreal, the initial negotiations were led by the Administration of a conservative U.S. President, and implementation was carried through under both Republican and Democratic Administrations (and during periods when first the

Democrats and then the Republicans controlled Congress). The Montreal Protocol was never an issue in Presidential or Congressional politics. Success entailed buy-in from and cooperation among ODS producers, industrial users, and environmental NGOs.

6. It is important that the science not be politicized. Although a few scientists were ozone “skeptics,” the reality of the ozone depletion threat never became a media issue. There was no special-interest funding of advertising about the uncertainties of the science (as has happened in the climate case). It is not clear whether there is any role for policy here; avoiding politicized science is more a matter of responsible journalism and scholarship.

7. Social and professional networks connecting corporate, NGO, and government personnel played a major role in the spread of information, the diffusion of innovations, and creation of incentives for ODS replacement. The process was not entirely (or even primarily) market-driven. Being a leader within one’s organization for ODS elimination came to be seen as a positive career move, so that personal and social objectives were mutually reinforcing. This was possible because of a firm regulatory commitment on the part of the Parties to the Protocol. Responsibility to future generations was asserted, and the non-economic dimensions of business activity and human life were affirmed.

8. Coordination between the ozone layer and climate protection efforts is essential. This is not only because the ODSs are themselves powerful greenhouse gases (it is estimated that the Montreal Protocol has removed “5 Kyotos’ worth” of global warming potential from the atmosphere), but because provisions in one Protocol can inadvertently undermine the other if there is no coordination. An example is the way it is currently profitable for developing countries to expand production of the ozone-depleting chemical HCFC-22 (which they are allowed to do under Montreal’s grace period) in order to get Clean Development Mechanism funds for destroying the greenhouse gas HFC-23 that is a byproduct of HCFC-22 production. A unified approach would eliminate such perverse incentives.

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