Economic Growth in a Clean-Energy Renaissance

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Organization Acronyms (in order of reviewed studies)

AA – Apollo Alliance .... Washington, D.C.
IAF – Institute for America's Future .... Washington, D.C.
COWS – Center on Wisconsin Strategy .... Madison, WI
MISI – Management Information Services .... Washington, D.C.
ASES – American Solar Energy Society .... Boulder, CO
JEI – Jobs and the Environment Initiative .... New York, NY
EPI – Economic Policy Institute .... Washington, D.C.
CSE – Center for a Sustainable Economy .... Washington, D.C.
ACEEC – American Council for an Energy Efficient Economy .... Washington, D.C.
UCB – University of California at Berkeley .... Berkeley, CA
UCS – Union of Concerned Scientists .... Cambridge, MA
NLF – New Labor Forum .... New York, NY
RAEL – Renewable and Appropriate Energy Laboratory .... Berkeley, CA
WB – The World Bank .... Washington, D.C.
BI – The Breakthrough Institute .... Oakland, CA
CAP – Center for American Progress .... Washington, D.C.
WEFA – Wharton Econometrics Forecasting Associates .... Waltham, MA
(now Global Insight)

1. Introduction

1.1 Proactive Growth

While reducing greenhouse gas emissions may be the greatest challenge of this century, that challenge presents the United States with an enormous opportunity for economic renewal. By confronting it proactively, the shift towards a low-carbon economy is not only affordable but beneficial, stimulating economic growth, enhancing national energy security and capitalizing upon the benefits of a stabilized climate.

Despite a robust body of evidence supporting the economic viability of addressing atmospheric carbon, the discussion surrounding global warming has been dominated by rhetoric of fear, catastrophe and sacrifice. The message of present sacrifice to prevent greater losses in the future is both politically untenable and in fact counterproductive. This rhetoric of sacrifice has strengthened the oppositional claim that any serious measure to reduce greenhouse gas emissions will have a negative impact on our economy.

It is increasingly clear, however, that these dire claims are unfounded. A careful examination of the literature highlights two crucial methodological flaws in the majority of studies predicting negative macroeconomic impacts. First, some such studies rely primarily on the impact of only a *single* policy instrument, for example a simple carbon tax. These studies calculate the impact of imposing a carbon charge on the domestic economy without including the balancing effect of policy tools designed to constructively utilize the revenue generated from that tax or trading system, such as revenue recycling or federal investment. Such a one-sided calculation based upon dubious assumptions invariably yields a devastating forecast, and fails to recognize the potential economic benefits and opportunities resultant from a more comprehensive policy approach. Secondly, other studies take a microeconomic approach to examine a carbon tax's effects upon a single sector (frequently a fossil-fuel industry). These studies then extrapolate their microeconomic results into macroeconomic generalizations, implying that job losses in the bituminous coal sector are emblematic of every US market under proposed carbon plans. The political atmosphere created by both of these simplistic predictions reinforces the rhetoric of sacrifice that has heretofore plagued American discourse on global warming. This has significantly impeded the proactive and comprehensive policy response needed to capitalize upon the opportunities that carbon-savvy economic transformation presents to the United States.

Therefore, a shift in the discussion on confronting climate change is required, and the direction of that shift is clear. We must stop using the language of sacrifice and begin using the language of opportunity. An inspirational new focus on employment potential, new investment opportunity, GDP growth and enhanced energy security can generate the momentum necessary to propel the United States into a position of global leadership on climate stabilization and energy innovation. The benefits of such a position will be immense. For the United States to thrive in a globally interconnected world we must seize this opportunity to strengthen ours domestic economy as well as to recast ourselves politically on the world stage. We must boldly confront this unprecedented global challenge, and in doing so, reaffirm the ingenuity, compassion and productivity of the United States.

1.2 Benefits of a stable, long-term policy framework

The better we articulate a coordinated and comprehensive policy package, the greater the economic and environmental benefits we will earn in shifting toward a clean economy. A well-articulated and consistent policy framework will ensure effective private sector participation, reduce long-term risk and facilitate private capital investment in efficiency and renewable energies. If the private sector is confident about the new energy policy, companies will competitively seek out new market opportunities, investment options and growth potential. Clean-energy and energy efficiency technologies developed domestically will reinforce our currently weakened trade balance, opening new export markets and furthering the shift by developing nations to a low-carbon economy. As the United States proactively combats climate change with growth-positive and job-producing policy, the international community will continue its long history of emulating the world's largest economy. Policies enacted within the US will thereby result in positive economic impact both at home and abroad, capturing the benefits of energy security, a stable climate, and creating new opportunities for global prosperity.

1.3 Transitional Costs

Of course, there will be transitional costs associated with such a broad shift towards clean energy sources and a low-carbon economy. Certain sectors will be disproportionately impacted, both in revenue and employment. However, the transitional costs associated with these disruptions are clearly affordable, as little as 1% of total revenue generated from carbon policy (Barrett and Hoerner 2002) and are far outweighed by the overall positive economic impact.

The political utility of such transitional assistance is especially clear in context of the repeated, and often successful, appeals of opposition groups citing the impact on the American worker and blue-collar communities. Arming any proposed policy package with a comprehensive, generous and affordable transition assistance program would generate crucial support among the workers of affected industries while invalidating oppositional claims of disproportionate and inequitable impact on certain sectors.

1.4 Social Justice and Transitional Assistance

Any policy package must incorporate an element of social justice to fully address to the socioeconomic implications of both climate change and its mitigation. The poorest parts of our population are also the most vulnerable to the negative effects of unchecked climate change. They possess the least economic flexibility to absorb the burden of short-term increases in energy costs, and are therefore inclined to oppose any measure that can be seen as an unfair distribution of that necessary burden. We must recycle revenue generated from carbon sales into transitional assistance for individuals, businesses, and institutions in order to mitigate the short-term costs of shifting towards a low-carbon economy. These measures are crucial to fulfilling our moral obligations to the American people and to ourselves as we transition into a clean energy paradigm for the twenty first century.

1.5 Comprehensive Policy to Capture Economic Benefits and Confront Climate Change

Reducing global carbon emissions and avoiding the worst effects of climate change is among the most complex and multifaceted challenges in human history, so any policy package seeking to address it must be equally comprehensive.

While the details of implementation will be determined through the legislative process, we feel confident recommending the following policy tools as essential components of any future climate and energy legislation. The policy package discussed in this paper is an aggregate of policy recommendations common to, in our opinion, the best research and literature available. The goal of this paper is to synthesize those recommendations and assess their impact on the macroeconomic level, looking specifically at job creation, GDP growth, consumer energy savings, energy security and balance of trade. The policy package has five essential components, which are as follows:

1. A legally-binding cap-and-trade system that auctions 100% of its carbon permits, and that yearly defines the quantity of those permits according to the emissions reductions targets guided by science;

2. Aggressive federal and private investment framework in R&D, technology deployment, efficiency and job creation;

3. Revenue recycling policies designed to mitigate the impact of the short-term rise in consumer energy prices associated with pricing carbon and stimulating economic growth;

4. Creation of a transitional assistance fund for workers and communities in adversely impacted sectors; and

5. Regulatory increases in efficiency standards for transportation, equipment, appliances, building and land use.

6. Policies preserving the competitiveness of American firms by extending the price of carbon to goods and materials outside of the regulatory jurisdiction of the United States.

These policies and others will have to be implemented under a coordinated federal framework to confront and capture the opportunities of climate change. These policies must be seen as domestic forerunners of an internationally binding legal framework, including global emissions-reduction targets and worldwide investment in a clean-energy economy. The determined leadership of the United States on this global issue is likely to greatly accelerate the pace of such international cooperation, ensuring the feasibility of an effective and timely global response.

1.6 Potential Benefits of a Stabilized Climate and Secure Energy Future

Should these policies be implemented effectively, the United States has a unique opportunity to become a global leader in the fight to preserve climate stability. We have the opportunity to capture the incalculable benefits of a stabilized climate and a secure energy future; we have the chance to create millions of new jobs while stimulating economic growth. The estimated costs of doing nothing to prevent climate instability are profound, as are the opportunity costs of ignoring this historic opportunity. The time to act is now.

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2. Job Growth

Green Job [green jŏb] *noun*

Employment generated by activity that reduces greenhouse gas emissions

2.1 American Green Jobs

Since Americans support the creation of new jobs, Americans should support policies to reduce emissions of greenhouse gases (GHGs). Contrary to the popular assumption that emissions relief will spur unemployment, study after study has shown that a clean-energy economy will launch millions of new jobs in both blue- and white-collar industries, from manufacturing to engineering, construction, and technical services. This section will outline the findings of eight prominent studies that have forecasted the effects of GHG relief policies on the U.S. labor market. Because each uses different baseline figures and policy assumptions, it is difficult to compare them directly. However, a qualitative synthesis of their conclusions points toward a bright future for American business: a continuation of normal job growth and the potential for massive growth economy-wide.

Each of the studies examined here defines green employment differently, and in general, those assessing a more comprehensive array of industries and job descriptions predict the largest employment growth based upon clean-energy policy. The discrepancy lies in the vast interdependencies of the American economy, and the extent to which growth in renewable energy will stimulate employment in the transportation, construction, and retail industries, among many others. As such, the "green job" label extends from wind-turbine technicians and solar-panel engineers to include all of the supporting employment necessary for American companies to operate in carbon-reducing ways and to produce carbon-slim products. Under this comprehensive definition, cafeteria workers at a solar-panel factory are green employees, as are auto workers who build low-emissions vehicles. These jobs contribute to GHG relief, and thereby contribute to America's flourishing clean-energy economy. In short, the most reliable assessment of green employment considers the trickle-down effects of clean-energy growth.

Green employment is not a new phenomenon in the U.S. market. In 2003 the environmental protection industry was estimated to employ roughly 5 million people (Bezdek& Wendling 2006, 1).

By 2006 the renewable energy and energy efficiency (RE & EE) sub-industry alone had grown to support nearly 8.5 million jobs (Bezdek 2007, 5). Green industry and associated jobs are on a fast and steady upward course in the American economy, and with greater support from federal policy these employment figures could multiply many times over in the next decade.

While job losses in certain industries will be inevitable (chiefly in dirty energy industries such as coal mining), new jobs in clean-energy industries will easily displace them. The National Mining Association reports that there were 82,959 workers employed by coal mining in 2006, while the U.S. Census reports 101,380 jobs in petroleum and coal manufacturing for the same year. It is ironic that the fossil fuels industry employs so few Americans, especially given our currently disproportionate geopolitical and –economic dependence upon these fuels. However, as we leave our fossil economy behind, it will be necessary to make sure that former coal, oil, and natural gas workers are not left in the shadow of skeleton oil rigs. Most clean-energy policy recommendations include transitional funds to provide temporary support for those laid off, and to pay for training that will allow workers access to new industries and more skilled, higher-paying jobs in clean industry. For the most part, revenue streams internal to the policy package cover these transitional funds, preventing any additional tax burdens on Americans.

It is important to note that the vast majority of jobs resulting from the fossil energy industry can very easily accommodate clean fuels and other types of clean energy. Truck drivers transporting gasoline to service stations can haul a different, clean liquid fuel with no modification to their job description just as easily as service station attendants can sell a different fuel, too. Transmission line workers will be unlikely to notice when their wires carry electricity no longer produced by coal but now from wind, solar, or geothermal energy. And a steam turbine technician working in a coal plant can easily transition to an equivalent turbine at a concentrating solar, geothermal, or even nuclear power plant. For the average working American, moving into a clean-energy economy will require relatively little transition of skill sets or job descriptions, making the growth not only painless but also rewarding and hopeful.

Although most comprehensive studies of employment effects from clean-energy policy point to a net increase in jobs economy-wide, even normal job growth (e.g. zero net gains above business-as-usual projections) would make policy advantageous on the whole. The advantages of GDP growth, consumer energy savings, and new products exportable worldwide must all be considered, not to mention benefits from alleviating environmental deterioration and public health problems. Modern clean-energy policy can keep the American economy in track with current growth estimates, and even surpass these projections while providing a clean, healthy, and environmentally stable world for coming generations.

2.2 Studies Reviewed

New Energy for America The Apollo Jobs Report: Good Jobs & Energy Independence

A Report to the Apollo Alliance
Jointly Produced by: The Institute for American's Future & The Center on Wisconsin Strategy
With Economic Analysis Provided by: The Perryman Group, Waco TX.
January, 2004

Although the primary interest of the Apollo Alliance is American energy independence, the policy outlined in the group's *Jobs Report* is based on renewable energy development and energy efficiency measures. This structure reiterates the point that energy independence and climate action are compatible interests. Apollo's proposal focuses around a 10 year, $300 billion federal investment to be doled out as incentives for efficiency measures, grants for researching new technology, and federal spending on infrastructure to support renewable energy development. This investment is expected to reduce nationwide energy consumption 16%, including reductions of 1.25 to 2.55 million barrels of transportation related petroleum each day. By 2015, 15% of electricity will come from renewable generation, rising to 20% by 2020. Carbon emission are expected to reduce 23% by 2015. (Apollo 2004, 9)

Apollo estimates that this investment will add more than 3.3 million new jobs to the American economy (table 1). In addition, the types of jobs needed to achieve its goals are largely blue collar and industrial, paying higher wages and offering better benefits than the average American job. They also note that investments in energy efficiency provide far more jobs, 21.5 jobs per $1 million, than investment in new natural gas generation which yields only 11.5 jobs per $1 million. Likewise, renewable energy generation provides four times as many jobs per megawatt of installed power compared with natural gas, and "40% more jobs per dollar invested than coal generation" (Ibid, 8).

Table 1. Forecasted growth in GDP, personal income,
and total jobs as a result of ten-year federal investments in selected initiatives

	Ten Year Federal Investment (Billions)	GDP Gain (Billions)	Personal Income (Billions)	Total Jobs
Total Apollo Package	**$313.72**	**$1430**	**$983.87**	**3,338,810**
Increasing Energy Diversity	$49.17	$414.956	$278.70	932,095
Investing in Industries of the Future	$75.5	$392.56	$255.06	900,673
Promoting High Performance Building	$89.9	$373.03	$250.17	827,260
Rebuilding Public Infrastructure	$99.15	$252.46	$169.93	678,781
Strengthening Renewable Energy Markets	$30.00	$156.99	$103.59	365,555
Development of Bio-Energy Resources	$6.00	$23.41	$15.94	53,487
Hydrogen Fuel Cell RD&D	$6.50	$17.34	$11.82	40,147
Developing a "Smart" Electrical Transmission Grid Pilot	$2.00	$202.97	$137.68	441,473
Integrated Gasification and Carbon Capture (Coal) R&D	$4.67	$14.25	$9.66	31,431
Promoting US Made Efficient Automobiles	$30.00	$42.01	$26.27`	128,885
Modernize Appliance Standards	$3.50	$9.53	$5.89	29,876
Manufacturing Efficiency	$42.00	$341.01	$222.88	741,912
Improved Financing	$1.00	$5.66	$3.76	12,607
Public Buildings/Public Benefits Fund	$10.80	$126.97	$85.27	278,567
High Performance Buildings Tax Credit	$42.00	$236.53	$158.55	527,153
High Performance Building R&D	$2.00	$3.81	$2.63	8,932
Low income Home Energy Assistance Program	$34.00	NA	NA	NA
Brownfield Redevelopment	$3.50	$9.28	$6.36	20,837
Regional Planning and Smart Growth	$8.15	$19.74	$13.19	50,520
New Public Transit Starts	$20.00	$50.07	$33.33	141,112
New High Speed Rail	$25.00	$63.37	$42.85	179,008
Rail Maintenance	$8.00	$21.96	$15.06	60,248
Road Maintenance	$5.00	$14.38	$9.78	38,386
Congestion Mitigation and Air Quality	$18.00	$44.75	$29.77	126,080
Water Infrastructure	$11.50	$28.91	$19.51	62,586

(table data: Apollo 2004, pp.13-29)

Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century

Roger Bezdek, Principle Investigator
Management Information Services, Inc.
Washington, D.C.
for the American Solar Energy Society
2007

Management Information Services and American Solar Energy Society's 2007 briefing on renewable energy and energy efficiency is a highly comprehensive study of that sector's current and forecasted employment. The report studies data from 2006 to define the scope of RE & EE, in which they include anything from "windows and doors to airliners and automobiles to home appliances and industrial motors," indeed "all aspects of renewable energy and energy efficiency, and include both direct and indirect jobs created in both these sectors" (Bezdek 2007, 2). The resulting baseline figures show nearly 8.5 million jobs in the combined industry in 2006 (table 2). These jobs include a broad array of occupations requiring varying levels of education and work experience (tables 3 and 4).

The report also forecasts employment in RE & EE in 2030 based on three growth scenarios: a base case in which the industry receives no government incentives or initiatives and a stable price for fossil energy sources, a moderate scenario in which federal and state governments institute moderate incentives for RE & EE development and electricity from RE sources makes up 15% of national supply, and an advanced scenario with strong RE & EE incentives and 30% RE (table 2). Results point to dramatic increases in employment in either the moderate or advanced scenarios, and the potential for 40 million new jobs and relatively modest growth under an energy portfolio sourced 30% renewably by 2030. Given such predictions for the "30 by '30" model, imagine the positive impacts of "80 by '50," the target scientists recommend to avoid the most catastrophic effects of climate change.

Although employment forecasted for RE & EE industry growth is impressive, the causes for these gains are unfortunately vague in this study. Bezdek mentions "government incentives" as the only policy on which employment forecasts are based.

Table 2. Summary of the U.S. renewable energy and energy efficiency industries in 2006, and forecasted growth in 2030 based on three policy scenarios.

	2006		2030					
Industry	**Revenues** (billions)	**Jobs** (thousands)	**Base** business as usual		**Moderate** 15% of electricity from RE sources		**Advanced** 30% of electricity from RE sources	
			Revenues (billions)	**Jobs** (thousands)	**Revenues** (billions)	**Jobs** (thousands)	**Revenues** (billions)	**Jobs** (thousands)
Renewable Energy	$39.2	452	$95	1,305	$227	3,138	$597	7,918
Energy Efficiency	$932.6	8,046	$1,818	14,953	$2,152	17,825	$3,933	32,185
TOTAL	$971.8	8,498	$1,913	16,258	$2,379	20,963	$4,530	40,103

(data: Bezdek 2007, p.5, Table ES1 and p.7, Table ES2)

Table 3.

Occupation	10 year % Growth Forecast	Median Salary	% With Bachelor's Degree	Education
Materials Scientists	8	$74,400	94	Bachelor's
Physicists	7	91,500	92	Doctoral
Microbiologists	17	63,400	96	Doctoral
Biological Technicians	17	36,500	60	Associate
Conservation Scientists	6	53,800	88	Bachelor's
Chemists	7	63,500	94	Bachelor's
Chemical Technicians	4	40,100	27	Associate
Geoscientists	6	73,200	94	Doctoral
Natural Science Managers	14	99,100	90	Bachelor's
Environmental Eng. Technicians	24	42,000	18	Associate
Soil and Plant Scientists	20	58,000	64	Bachelor's
Mechanical Eng. Technicians	12	46,500	18	Associate
Environmental Sci. Technicians	16	38,500	47	Associate
Biomedical Engineers	31	75,400	60	Bachelor's
Chemical Engineers	11	79,200	92	Bachelor's
Mechanical Engineers	10	77,000	88	Bachelor's
Electrical Engineers	12	76,000	83	Bachelor's
Environmental Engineers	14	74,500	82	Bachelor's
Computer Scientists	26	94,000	67	Doctoral
Life & Physical Sci. Technicians	20	45,200	50	Associate
Utility Plant Operatives	4	53,000	10	OJT
HVAC Technicians	12	37,600	14	OJT
Energy Audit Specialists	18	39,500	18	OJT
Forest and Conservation Workers	6	27,000	8	OJT
Refuse and Recycling Workers	5	26,000	2	OJT
Insulation Workers	6	30,200	2	OJT

OJT = On-the-Job Training

"Renewable Energy and Energy Occupations: Wages, Education Requirements, and Growth Forecasts, Selected Occupations" (caption: Bezdek 2007, p.45; table: Ibid, Table CS3)

Table 4.

Occupation	10 year % Growth Forecast	Median Salary	% With Bachelor's Degree	Education
Materials Scientists	8	$74,400	94	Bachelor's
Physicists	7	91,500	92	Doctoral
Microbiologists	17	63,400	96	Doctoral
Biological Technicians	17	36,500	60	Associate
Conservation Scientists	6	53,800	88	Bachelor's
Chemists	7	63,500	94	Bachelor's
Chemical Technicians	4	40,100	27	Associate
Geoscientists	6	73,200	94	Doctoral
Natural Science Managers	14	99,100	90	Bachelor's
Environmental Eng. Technicians	24	42,000	18	Associate
Soil and Plant Scientists	20	58,000	64	Bachelor's
Mechanical Eng. Technicians	12	46,500	18	Associate
Environmental Sci. Technicians	16	38,500	47	Associate
Biomedical Engineers	31	75,400	60	Bachelor's
Chemical Engineers	11	79,200	92	Bachelor's
Mechanical Engineers	10	77,000	88	Bachelor's
Electrical Engineers	12	76,000	83	Bachelor's
Environmental Engineers	14	74,500	82	Bachelor's
Computer Scientists	26	94,000	67	Doctoral
Life & Physical Sci. Technicians	20	45,200	50	Associate
Utility Plant Operatives	4	53,000	10	OJT
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Energy Audit Specialists	18	39,500	18	OJT
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Refuse and Recycling Workers	5	26,000	2	OJT
Insulation Workers	6	30,200	2	OJT

OJT = On-the-Job Training

"Typical Employee Profile of a 250-person Wind Turbine Manufacturing Company, 2006, Selected Occupations" (caption: Bezdek 2007, p.42; table: Ibid, Table CS2)

Environmental Protection, the Economy, and Jobs: What's the Bottom Line?

Roger H. Bezdek
Robert M. Wendling
Management Information Services, Inc.
Washington, D.C.
Puala DiPerna
Jobs and the Environmental Initiative
New York, NY
Revised Version Prepared for the *Journal of Environmental Management*, July 2006

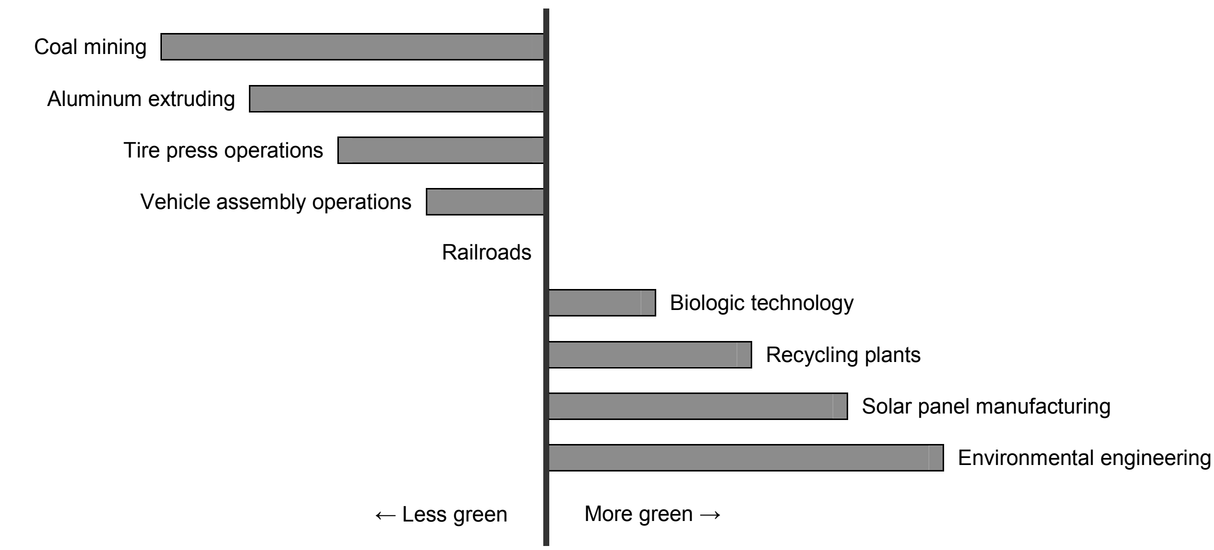
This report has five major findings:

1. National environmental protection policies result in net job creation as opposed to the popular assumption that they are harmful to job markets.
2. Environmental protection is a major force in the American economy, with sales of $300 billion per year and employment of 4.97 million in 2003.
3. The majority of these jobs are not stereotypically "environmental," with accountants, computer analysts, and factory workers representing the majority.
4. Environmental policy at the state level can be an economic boon to the state's economy.
5. Jobs created by environmental policies are concentrated in areas attractive to state economics, from manufacturing to professional information, scientific, and technical services.

These conclusions are based on results from an economic input-output model developed by Management Information Services, Inc. (MISI), extensive databases of employment and market information compiled by MISI, and analysis of previous studies.

The study found that, at the national level, expenditures in the environmental protection industry have expanded from $39 billion to $301 billion (in constant 2003 dollars) since the late 1960s – a much faster rate of growth than GDP over the same period (Bezdek, Wendling, & DiPerna 2006, 11). In a jobs-per-dollar metric, investments in environmental protection generate three to four times as many jobs in professional, scientific, and technical services compared with other industries, according to state averages (Ibid, 13). In 2003, the environmental protection workforce of 4.97 million people was more than ten times larger than that of the U.S. pharmaceuticals industry, nearly six times that of the apparel industry, three times greater than the chemical industry, half the employment of all U.S. hospitals, and about one third the size of the entire domestic construction industry (Ibid, 11).

Figure 1. The Environmental Jobs Spectrum



(Bezdek and Wendling 2006, p. 20, Figure 2.; original source: Management Information Services, Inc., 2006)

Clean Energy and Jobs: A comprehensive approach to climate change and energy policy

James P. Barrett
J. Andrew Hoerner
Steve Bernow
Bill Dougherty
Economic Policy Institute
Washington, D.C.
Center for a Sustainable Economy
Washington, D.C.
2002

In their 2002 report from the Economic Policy Institute and Center for a Sustainable Economy, Barrett and Hoerner estimate net job creation of 660,000 by 2010 and 1.4 million by 2020 based on a "modest" tax of $50 per ton of carbon phased in over a five-year period. Such a tax would raise $70-$80 billion per year when fully phased in. Barrett and Hoerner note that employment growth in this scenario is due primarily to additional growth in GDP of 0.6% by 2020, roughly $100 billion (see section on GDP, p.30).

These employment forecasts are somewhat more conservative than those of comparable studies (perhaps attributable to the smaller baseline size of the green economy at the publication date), but their model is one of the most sophisticated, and is therefore of note. The team used the 92-sector LIFT model, developed by the Inforum group, to forecast trends in GDP, employment, energy security, and GHG emissions across the US economy. The study claims to be the first to model the costs of transitional assistance to workers and communities disproportionately impacted by a carbon tax, and suggests that a portion of its revenues could wholly finance such assistance. The assistance package would include two years of income and benefit replacement to every worker who loses his or her job as a result of the tax, up to four years of training or college education, and $10,000 of development assistance per worker in hard-hit communities. The average estimated cost of this assistance package would total $122,000 per worker (with $196,000 for workers in the coal industry). Despite such generous individual assistance, the entire transition package will only require 1% of total revenue accrued from the proposed carbon tax (Barrett & Hoerner 2002, 13).

Making Green Policies Pay Off: Responsible climate-change package can benefit environment, workforce

James Barrett
Environmental Policy Institute
Washington, D.C.
Andrew Hoerner
Center for a Sustainable Economy
Washington, D.C.
EPI Issue Brief #143
April 21, 2000

This *EPI Issue Brief* from April, 2000, co-published by the Center for a Sustainable Economy, recommends that a carbon tax or 100% auction cap-and-trade system must be supplemented by auxiliary policies which recycle revenue from either of these systems to (1) cut other taxes, (2) promote RE & EE technologies and business development, and (3) provide transition assistance to those who lose their jobs. The report goes on to analyze economy-wide employment based on a $50/ton carbon tax[1], with revenue returned through per-capita rebates in payroll taxes, and policies to stimulate RE & EE development. The report divides the economy into 498 separate industries, and traces the impacts of the policy package to categorize each one for emerging as a "winner" or "loser" in the projected economy of the year 2020. It concludes that employment in "winner" industries is far larger than that in "loser" industries (table 5). Moreover, job growth in "winner" industries is much greater than losses in "loser" industries, with 260,000 jobs gained by 2020 as opposed to just 55,000 lost. It is a significant caveat, thought, that more than a quarter of these losses are likely to be union jobs (14,000), whereas only 7% of new employment (19,000) is likely to

[1] This model also added an "equalizing charge" to the price of electricity produced by nuclear power and large-head hydropower.

be unionized (Barrett & Hoerner 2000, 3). These figures are updated with further research in Barrett and Hoerner's 2002 article *Clean Energy & Jobs* (further discussed on page 16).

As they do in their other reports, Barrett and Hoerner note that transition assistance will be necessary to compensate "losing" industries, and they suggest this can be achieved sufficiently and "generous[ly]" at a rate of $102,932 per laid-off worker. Multiplied by 55,000 jobs lost, transition assistance amounts to roughly $5.7 billion, a mere 1% of annual carbon tax or permit revenues (Ibid, 4). They also note that border adjustments will be necessary to maintain international competitiveness on energy intensive products such as metals, ceramics, fertilizer, chemicals, and cement (Ibid, 4).

Table 5. Employment effects of climate policy package.

	Total Employment (thousands)	Union Employment (thousands)	Jobs Gained (thousands)	Union Jobs Gained (thousands)
"Winner" industries	168,138	16,266	260	19
"Loser" industries	15,862	3,290	-55	-14
Total	184,000	19,557	205	6

Note: Totals may not add due to rounding.

(Barrett and Hoerner 2000, p.3, Table 1; original data source: CSE/EPI analysis)

Job Creation and Environmental Protection

Roger Bezdek
Robert Wendling
Management Information Services
Washington, D.C.
Published in *Nature*, Vol. 434 No 7033 p678 (31 March 2005)

This short article in a 2005 edition of the journal *Nature* paraphrases the more comprehensive 2006 report by Bezdek and Wendling, *Environmental Protection, The Economy, And Jobs: What's the Bottom Line?* Its primary conclusion is that the environmental protection workforce was 5.1 million strong in 2004, much larger than previously estimated, and that it includes a varied cross-section of professions. Their survey indicated 55,000 jobs for electricians and 31,000 for accountants and auditors, pointing out that these occupations greatly outnumber environmental engineers and geoscientists with advanced and graduate degrees. Lastly, they highlight the concentration of environmental jobs in the manufacturing sector, noting that future growth in this industry may contribute to resurgence in American manufacturing.

More Jobs and Greater Total Wage Income: The Economic Benefits of an Efficiency-Led Clean-Energy Strategy to Meet Growing Electricity Needs in Michigan

John A. "Skip" Laitner
Martin G. Kushler
American Council for an Energy-Efficient Economy
Washington, D.C.
December 2007

This report forecasts employment increases as a result of a proposed EE&RE program in the state of Michigan. A January 2007 report by the Michigan Public Service Commission found that reducing total electricity use by 15% between 2008 and 2023, with 7% of the remaining portfolio provided by renewable sources, would be a feasible and worthwhile goal for the state. The program and administrative costs would require a fifteen-year investment of $7.2 billion and would save $9.2 billion in avoided electricity costs over the same period. Using an input-output economic model called the Dynamic Energy Efficiency Policy Evaluation Routine (DEEPER), the American Council for an Energy-Efficient Economy predicts that Michigan will see net annual employment increases of between 3,900 and 10,000 jobs as firms recycle energy savings through expansion. They note that these gains are equivalent to direct and indirect employment from construction and operation of some twenty-five to seventy-five small manufacturing plants. Because manufacturing and other business types employ many more people per dollar spent than do electric utilities or natural gas distributors, it makes sense to shift funds toward industry rather than toward energy suppliers (table 6).

These forecasts for Michigan may be qualitatively adapted to the national scale; energy efficiency is widely known to be a sound investment. Meanwhile, researchers are working to apply the DEEPER model to analyze nationwide efficiency plans.

Table 6.

Sector	Total Employment per Million Dollars of Spending	Total Wage and Salaries per Dollar of Spending	Total Gross State Product (GSP) per Dollar of Spending
Agriculture	17.2	0.207	0.638
Oil and Gas Extraction	6.1	0.125	0.718
Other Mining	6.9	0.370	0.661
Electric Utilities	2.8	0.201	0.773
Natural Gas Distribution	2.9	0.175	0.452
Construction	12.1	0.437	0.708
Manufacturing	5.4	0.311	0.511
Wholesale Trade	8.1	0.445	0.853
Transportation, Other Public Utilities	11.2	0.513	0.770
Retail Trade	19.1	0.480	0.841
Services	11.9	0.397	0.822
Finance	8.0	0.366	0.794
Government	17.1	0.845	0.970

Source: IMPLAN® (2007), a 2004 input-output database for Michigan
(Laitner and Kushler 2007, p.4, Table 1)

Economic Growth and Greenhouse Gas Mitigation in California

David Roland-Holst
UC Berkeley
August 2006

Roland-Holst's 2006 study on the potential for economic growth from climate policy is specific to the state of California, but his conclusions may serve as a model for nationwide economic growth if similar policies are implemented at the national level. Using the Berkeley Energy and Resources (BEAR) model to forecast market trends as affected by California climate action policy already under development, including the "California Global Warming Solutions Act" and 8 of the 34 policies recommended by the Climate Action Team (CAT)[2], the report makes three broad conclusions:

1. Participation in a GHG mitigation scheme must be mandatory (as opposed to voluntary credit trading systems) and include "all sectors representing a significant share of emissions," not just those directly related to fossil fuel products.

[2] Eight CAT Scenario Component Policies: (1) Building efficiency policies already underway. (2) Vehicle GHG policies already underway, (3) Refrigerant Process Efficiency, (4) Cement blending and efficiency measures, (5) Manure Management, (6) Semiconductor Industry Targets, (7) Landfill Management, (8) Afforestation (Roland Holst 2006, 23)

2. A regulatory and market-based emissions cap can feasibly reduce California GHG emissions to 1990 levels by 2020 while stimulating the economy.
3. Employment and growth can be further stimulated if the state provides direct incentives for investment in new technologies.

The report emphasizes that regulatory and market-based strategies are complimentary, and that both must be employed to maximize GHG reduction and economic stimulation.

Economic results include annual gains of $60 billion (+2.4%) in Gross State Product and 17,000 new jobs with policy to reduce emissions to 1990 levels by 2020. An additional $14 billion in GSP and 72,000 jobs per year can be gained if innovation incentives are established (table 7). These gains are derived from savings as a result of energy efficiency and benefits from spurred technological innovation.

More detailed results are presented based on specific policy scenarios (table 8):

[1] Baseline (no emissions reduction target)

[2] 8 CAT policies (direct regulation)

CAT policies plus emissions cap to meet remainder of 2020 target

[3] Industries in Group 1 covered by an aggregate cap (table 9)

[4] Industries in Groups 1 and 2 covered by aggregate cap

[5] Industries in Groups 1, 2, and 3 covered by aggregate cap

[6] 8 CAT policies plus emissions cap on industries in Groups 1, 2, and 3 with revenues recycled into innovation investment

[7] 8 CAT policies plus emissions cap on all emitting industries with revenues recycled into innovation investment

Table 7. Macroeconomic Impacts of 8 CAT policies plus a 2020 GHG Cap
(1990 GHG Emissions Levels by 2020)

Annual Impact	8 CAT policies + CAP	8 CAT policies + Cap with innovation incentives
Gross State Product (2006 dollars) % change from 2020 baseline	**+$60 Billion** (+2.4%)	**+$74 Billion** (+3.1%)
Employment (thousands) % change from 2020 baseline	**+17** (+0.08%)	**+89** (+0.44)

(Roland-Holst 2006, 3)

Table 8. Macroeconomic Impacts

Scenario	2 CAT	3 Group 1	4 Group 1,2	5 Group 1,2,3	6 Revenue Rcy.	7 All Ind.
Total GHG*	-13	-28	-28	-28	-28	-28
Household GHG*	-32	-32	-32	-32	-31	-30
Industry GHG*	-3	-26	-26	-26	-26	-27
Annual GSP Growth*	2.4	2.4	2.4	2.4	3.1	4.7
Employment*	0.10	0.06	0.08	0.08	0.44	1.07
Jobs	20,000	13,000	16,000	17,000	89,000	219,000
% of GHG Target	47	101	100	100	100	100

* Percent change from Baseline scenario in the year 2020

(Roland-Holst 2006, 26)

Table 9. Alternative Industry Emissions Groups

1.	**Group 1: First Tier Emitters**
	Electricity Suppliers
	Oil and Gas Refiners
	Cement
2.	**Group 2: Second Tier Emitters**
	Agriculture
	Construction of Transport Infrastucture
	Wood, Pulp, and Paper
	Chemicals
	Metal Manufacture and Fabrication
	Aluminum Production

3.	**Group 3: Other Industry Emitters**
	Cattle Production
	Dairy Production
	Forestry, Fishery, Mining, Quarrying
	Oil and Gas Extraction
	Other Primary Activities
	Generation and Distribution of Electricity
	Natural Gas Distribution
	Water, Sewage, Steam
	Residential Construction
	Non-Residential Construction
	Food Processing
	Textiles and Apparel
	Printing and Publishing
	Pharmaceuticals
	General Machinery
	Air Conditioner, Refrigerator Manufacturing
	Semiconductors
	Electrical Appliances
	Automobiles and Light Trucks
	Other Vehicle Manufacturing
	Aeroplane and Aerospace Manufacturing
	Other Industry

(Roland-Holst 2006, 21)

Creating Jobs, Saving Energy, and Protecting the Environment: An Analysis of the Potential Benefits of Investing in Efficient Cars and Trucks: A 2007 Update

Union of Concerned Scientists
Cambridge, MA
2007

This report from the Union of Concerned Scientists forecasts the economic effects of increasing the fleetwide average fuel consumption for cars and trucks in the U.S. to 35 miles per gallon by 2018. They say that this average can be achieved by implementing existing technologies such as more efficient engines, transmissions and tires, high strength metals, and hybrid-electric powertrains. An earlier report (2004) indicated that an average of 40 miles per gallon by 2015 was similarly attainable and economically beneficial, but "this study shifts to lower and later targets" (UCS 2007, 2).

Benefits from implementation of efficiency standards include billions of dollars of fuel savings for consumers, reduced greenhouse gas emissions, and high return on investment for the automobile industry, especially in the form of new jobs. They predict that 241,000 new jobs would be created by 2020 economy-wide, with California, Texas, Florida, New York, Michigan, Ohio, and Illinois each gaining more than 10,000. The automotive sector would see 23,900 new jobs by 2020. Consumers would see annual at-the-pump savings of roughly $37 billion by 2020, by which time our oil consumption would have decreased by 1.6 million barrels per day resulting in carbon reductions equivalent to removing 40 million cars and trucks from the road.

The study was carried out using IMPLAN, a macroeconomic analysis tool that analyzes interactions between 528 industrial sectors given 21 economic variables to estimate fluctuation in employment, wages, and GDP over time. The effect of both direct and indirect investments and spending of fuel cost savings were analyzed on a national basis and projected results were apportioned by state based on gasoline consumption and pricing data and industry-level employment projections (tables 10 and 11). A parallel study was carried out to asses the effects of an even more conservative policy: 35mpg standards by 2020.

Table 10. Job Growth by Industry Using Technology to Reach Mileage Standards

	35mpg by 2018		35mpg by 2020	
Industry	**2020** Net Increase in Jobs	**2030** Net Increase in Jobs	**2020** Net Increase in Jobs	**2030** Net Increase in Jobs
Agriculture and Food Processing	9,700	15,100	6,700	14,100
Construction	16,500	29,400	11,200	27,200
Finance, Insurance, and Real Estate	33,100	44,200	25,600	41,200
Government and Education	28,600	59,300	16,800	54,600
Manufacturing (excluding motor vehicles)	17,800	18,300	14,600	17,300
Mineral/Resource Mining and Petroleum Refining	-21,000	-27,000	-17,100	-25,200
Motor Vehicles	23,000	21,100	22,300	20,000
Retail Trade	44,400	68,200	27,200	62,900
Services	82,900	121,800	60,700	133,100
Transportation, Communication, and Utilities	12,500	26,200	9,000	24,300
Wholesale Trade	-7,400	-6,300	-6,200	-5,900
Total	**241,000**	**370,300**	**170,800**	**343,600**

(UCS 2007, 3-9)

Table 11. Job Growth and Consumer Savings By State in 2030
Using Technology to Reach 35 mpg by 2018

State	Net Savings (millions)	New Jobs	State	Net Savings (millions)	New Jobs
Alabama	$1,493	5,800	Montana	$236	1,100
Alaska	147	600	Nebraska	472	2,200
Arizona	1,572	6,900	Nevada	629	2,800
Arkansas	786	3,200	New Hampshire	393	1,700
California	9,117	50,600	New Jersey	2,436	10,900
Colorado	1,179	5,600	New Mexico	550	2,000
Connecticut	943	4,900	New York	3,222	20,000
Delaware	236	1,100	North Carolina	2,436	11,300
Washington, D.C.	79	1,100	North Dakota	157	800
Florida	4,873	22,400	Ohio	2,908	15,300
Georgia	2,908	11,600	Oklahoma	1,022	3,000
Hawaii	236	1,600	Oregon	865	4,400
Idaho	314	1,500	Pennsylvania	2,908	15,200
Illinois	2,908	15,600	Rhode Island	236	1,100
Indiana	1,808	8,800	South Carolina	1,415	5,700
Iowa	865	3,900	South Dakota	236	1,000
Kansas	629	3,000	Tennessee	1,729	24,200
Kentucky	1,258	5,400	Texas	6,602	3,000
Louisiana	1,336	4,200	Utah	550	800
Maine	393	1,700	Vermont	236	10,100
Maryland	1,493	7,200	Virginia	2,279	8,000
Massachusetts	1,651	8,600	Washington	1,572	1,800
Michigan	2,829	14,800	West Virginia	472	7,200
Minnesota	1,493	7,000	Wisconsin	1,415	500
Mississippi	943	3,200	Wyoming	157	1,100
Missouri	1,808	8,100			

(UCS 2007, 8)

The Economic Promise of Renewable Energy

George Sterzinger
Published in the New Labor Forum, 16:3, 80-91
June 1, 2007

Sterzinger's 2007 article on the potential for growth in the renewable energy industry highlights the new jobs that could be created as a result of new energy policy. "Unlike fossil energy, which is discovered," he notes, "renewable energy is conceived and created in labs and universities , brought to commercial readiness by developers, manufactured as component parts, and assembled into finished products" (Sterzinger 2007, 81). In short, the 'hands-on' renewable energy industry has much greater potential to support an industrial workforce than do fossil fuels. He predicts that by 2017 investment in the renewable energy industry will exceed $160 billion and support the creation of more than 2 million new full-time equivalent jobs (2,000 hours of labor per year). He also notes that these jobs would concentrated in states that have suffered recent losses in manufacturing positions such as California, Illinois, and Texas, and are especially in need of blue-collar jobs. He claims that ten states alone may capture over a quarter of employment gains (524,558 out of 2 million anticipated new positions) (table 12).

According to Sterzinger, government investment, alongside caps on carbon emissions, is the most productive way to prompt greenhouse gas emissions. He notes that like most economic scenarios, carbon reduction must be thought of in terms of interaction between a principle and an agent. The Government, should act a principle who, "on behalf of society[,] wants energy produced and used in a sustainable way" and is willing to provide direct investments and incentives to private agents, the renewable energy industry, to get the job done (Sterzinger 2007, 84). As such, the government becomes the voice of the people, for whom businesses work, rather than the other way around.

Table 12. The Top Ten: New Investment Potential Versus Manufacturing Job Losses in the United States

State	Number of Potential New Jobs	Average Investment ($ billions)	2001 Population	Rank in U.S. in population	Manufacturing Jobs Lost, Jan. 2001 – May 2004	Rank in U.S. in number of jobs lost
California	95,616	$20.90	34,501,130	1	318,000	1
Texas	60,100	$13.22	11,373,541	7	165,500	3
Illinois	56,579	$9.93	21,325,018	2	169,600	2
Ohio	51,269	$8.84	9,990,817	8	129,300	8
New York	47,930	$8.40	12,482,301	5	131,500	6
Pennsylvania	42,668	$7.92	6,114,745	14	63,500	13
Indiana	39,221	$6.26	12,287,150	6	155,200	5
Michigan	34,777	$5.53	5,401,906	18	68,300	10
North Carolina	28,544	$5.33	19,011,378	3	130,500	7
Missouri	22,796	$5.96	8,186,268	11	156,600	4
10 State Total	**524,558**	**$91.59**	**140,674,254**		**1,488,000**	
% U.S. Total	**65%**	**57%**	**50%**		**55%**	

(Sterzinger 2007, 86)

Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?
Daniel M. Kammen
Kamal Kapadia
Matthias Fripp
Energy and Resources Group
Goldman School of Public Policy
University of California Berkeley
A Report of the Renewable and Appropriate Energy Laboratory
April 13, 2004

Like our paper, Kammen, Kapadia, and Fripp's report on employment potential in the 'clean energy industry' is a literature review with the goal of compiling and comparing results from a mounting body of work on this topic. To increase the combined scope of our papers we focused on articles not reviewed by Kammen and his colleagues, with the single exception being The *Apollo Jobs Report* (see page 10). It should be noted that Kammen, Kapadia, and Fripp place significantly more emphasis on comparing results from different articles side-by-side, a difficult endeavor when each uses different variables, models, and policy packages to make forecasts. Our paper places much more emphasis on the presentation of major findings from a variety of studies, allowing readers to gauge general trends in macroeconomic forecasts and point them in the direction of primary sources for more in-depth review.

Putting Renewables to Work is an extremely comprehensive analysis of thirteen studies written between 1998 to 2004 to forecast the macroeconomic effects of proposed climate policies. The report asks four primary questions:

1. How can employment forecasts from different studies be compared when they are derived so differently?
2. How would potentially large-scale growth the renewable energy (RE) sector impact regional employment?
3. How would large-scale RE growth impact employment in the fossil fuel energy sector?
4. What policies would maximize the employment and economic benefits of an RE industry?

The first question was addressed by combining results from each study based on the energy technologies – photovoltaic, wind, biomass, coal, or gas – for which they provide job creation forecasts. To make employment projections comparable between technologies, they were converted to a common unit: Jobs/Megawatt hour produced (table 13).

To answer the last three questions, employment figures for each technology were combined to forecast employment in 2020 based on five policy scenarios including three

Renewable Portfolio Standards (RPSs), business as usual, and natural gas intensive (table 14). A 20% RPS made up of 85% biomass, 14% wind, and 1% photovoltaic, supported the most employment with 240,850 new jobs nationwide. An intensive natural gas policy, with 20% of national electricity coming from natural gas, created the least employment with 83,987 jobs. The report's general conclusion simply amplifies those of the articles it reviews: renewable energy production creates more jobs than fossil energy production per unit of energy produced. However, its success with combining and comparing the result of multiple studies is a major achievement which strengthens the validity of their individual claims.

Kammen and his colleagues also conclude that employment in the fossil fuels industry is already declining for reasons independent of policy to encourage RE, suggesting that the industry is no longer contributing positively to the American job market. Job losses will be inevitable in any form of transition to an RE economy, and can be adequately addressed with transitional fund policies. Additionally, they suggest that policy to support RE development should be embedded within larger policy encouraging for energy efficiency to have maximum positive impacts on employment.

Table 13. Average employment for different energy technologies

Energy Technology	Source of Estimate	Average Employment Over Life of Facility (jobs / $MW_{produced}$)		
		Construction, Manufacturing, Installation	O&M and fuel processing	Total Employment
PV 1	REPP, 2001	6.21	1.20	7.41
PV 2	Greenpeace, 2001	5.76	4.80	10.56
Wind 1	REPP, 2001	0.43	0.27	0.71
Wind 2	EWEA/Greenpeace, 2003	2.51	0.27	2.79
Biomass – high estimate	REPP, 2001	0.40	2.44	2.84
Biomass – low estimate	REPP, 2001	0.40	0.38	0.78
Coal	REPP, 2001	0.27	0.74	1.01
Gas	Kammen, from REPP, 2001; CALPIRG, 2003; BLS, 2004	0.25	0.70	0.95

(Kammen, Kapadia, and Fripp 2004, 1)

Table 14. Comparison of the estimated employment created by meeting the equivalent of 20 percent of current U.S. electricity demand via an expansion of fossil or renewable-based electricity generation

Scenarios	Average employment associated with each scenario (jobs)		
	Construction, Manufacturing, Installation	O&M and Fuel Processing	Total Employment
Scenario 1: 20% Renewable Portfolio Standard (RPS) by 2020 (85% biomass, 14% wind energy, 1% solar PV)	52,533	188,317	240,850
Scenario 2: 20% Renewable Portfolio Standard (RPS) by 2020 (60% biomass, 37% wind energy, 3% solar PV)	85,008	91,436	176,444
Scenario 3: 20% Renewable Portfolio Standard (RPS) by 2020 (40% biomass, 55% wind energy, 5% solar PV)	111,879	76,139	188,018
Scenario 4: Fossil Fuels as Usual to 2020 (50% coal and 50% natural gas)	22,711	63,657	86,369
Scenario 5: 20% Gas Intensive by 2020 (100% natural gas)	22,023	61,964	83,987

(Kammen, Kapadia, and Fripp 2004, 2)

3. GDP Growth

3.1 The Cost of Doing Nothing

If we continue to emit carbon unabatedly into the 21st century, the costs to GDP will mount dramatically as we struggle to cope with an unstable climate. Baseline growth forecasts for GDP, projecting business as usual without including the costs of a destabilized climate, predict aggressive annual growth amounting to a 238% increase in US GDP by 2050 (EIA 1998). But the costs to GDP by unchecked climate change would injure GDP over the same time period, wiping out years of promising growth potential and weakening the global economy (Stern Review, World Bank 2006).

In meeting the challenge of climate change with a comprehensive policy package aimed at stimulating investment, job growth and energy efficiency measures will assure a robust economy and national energy security. Furthermore, the same initiatives will also preserve GDP growth and even modestly increase real GDP in the near future.

3.2 Studies Reviewed

Clean Energy and Development: Towards an Investment Framework

Environmental and Socially Sustainable Development Vice Presidency
Infrastructure Vice Presidency
The World Bank
Washington, D.C.
April 5, 2006

The globalizing world economy, national markets are increasingly interdependent, and economic markers in one region influence those around the globe. For this reason, the World Bank discusses developing countries' present vulnerability to climate irregularities because such liabilities will soon ripple across the global economy (World Bank 2006, 27-28). It makes clear that beginning with significant losses in the Third World, an unstable climate will bruise worldwide GDP.

The World Bank also predicts economic duress as a direct function of global temperature gain (World Bank 2006, Annex K). Upon atmospheric warming by "2° to 3°C, the impact on developing countries increases rapidly, with estimates often up to 5—10 percent reduction in GDP or much lower" (Ibid). In other words, further greenhouse gas accumulation will so destabilize developing nations that the costs of addressing its symptoms—from sea-level rise to agricultural unpredictability—will swell to an appreciable percentage of global GDP. The report offers "a 'ball-park' estimate of the costs of additional impacts and adaptation" for developing nations:

> Several studies have suggested that the costs of impacts of climate change without adaptation could amount to several percent of GDP to tens of percent annually in exposed developing countries. Taking 0.5 percent of developing-country GDP as a modest estimate of the identified additional costs of impacts of a 2 or 3°C temperature increase, this would amount to some $40B per year but it could range from only a few billion to up to $100B (Ibid).

As such, the World Bank makes very clear that carbon relief in years to come will *protect* GDP measures around the world.

Fast, Clean, and Cheap: Cutting Global Warming's Gordian Knot

Ted Nordaus
Michael Shellenberger
Jeff Navin
Teryn Norris
Aden Von Noppen
Breakthrough Institute
Washington, D.C.
article will appear in the *Harvard Law and Policy Review*, January 2008
2007

Having surveyed a range of potential climate policies, Nordhaus and Shellenberger note that "one study conclude[s] that 'Investments in climate-friendly technologies can reduce GDP losses to the U.S. by a factor of two or more' (Richels et al, 2007), a conclusion broadly echoed by the Stern Review, the IPCC, and other analysts (Stern 2006; IPCC 2007; Edmonds and Smith, 2006; Grubb 2004; Nemet 2007)" (Nordhaus and Shellenberger 2007, 24). Like the World Bank Group, Nordhaus and Shellenberger find that the costs of a late-game triage approach to ameliorating the symptoms of climate instability will be much greater—"by a factor of two or more"—than seizing the opportunity to quell its cause right now. Furthermore, they repeatedly refer to economic evolution as an opportunity for American growth and prosperity.

Capturing the Energy Opportunity: Creating a Low-Carbon Economy

John Pedosta
Todd Stern
Kit Batten
Part of *Progressive Growth*, CAP's Economic Plan for the Next Administration
Center For American Progress
November 2007

This report also projects better implications for global GDP, contingent upon current proactivity versus reactivity in the future. It grounds such an argument in the commanding Stern Review, which "estimates that a robust set of policies aimed at holding greenhouse gas concentrations to around 550 parts per million of CO_2e are likely to cost about 1 percent of global GDP per year by 2050" (Podosta, Stern, & Batten 2007, 22-24) [3]. Sir Nicholas Stern's 700-page study of October 2006 is widely considered one of the most authoritative reports on the realities of climate change and its economic mitigation. Therefore, it carries great weight that "the Review also makes clear that the economic costs of failing to act are likely to be many times higher" (Ibid).

3.3 Comprehensive carbon-cutting policy and the American GDP

Whereas several studies assess the future of American gross domestic product if we do *not* mitigate carbon now, a great deal of research also projects GDP figures *after* the implementation of various carbon-cutting policy tools. These reports form three categories:

a. Studies projecting seriously negative GDP. The methodology of these reports tests for the macroeconomic implications of one blunt policy tool.

b. Studies projecting little variation in GDP between their "baseline" (business-as-usual under a theoretically stable climate) projections versus GDP after a balanced suite of carbon-reducing policies. These studies emphasize that carbon-cutting economics will award the US with a stabilized climate as well as continue current patterns of GDP growth.

c. Studies projecting significant GDP growth. These studies also explore multifaceted policy packages, with particular focus on public investment in efficiency and renewable energies.

[3] CO_2e: The potential of any atmospheric substance to act as a greenhouse gas (CO_2e,) is measured against carbon dioxide (CO_2)'s equivalent potential.

3.3a Singularly negative studies

Global Warming: The High Cost of the Kyoto Protocol: National and State Impacts
WEFA, Inc. (now Global Insights, Inc.)
1998

The High Costs of Distorted Economic Modeling
James P. Barrett
Appeared in the Journal of Commerce
February 7, 1999

WEFA, Inc. advised against US ratification of the Kyoto Protocol in a 1998 study, estimating that the treaty would "reduce US total output $300 billion (1992$) annually, 3.2% below baseline GDP projections"(WEFA 1999, 1). However, the study postulates nothing more than a carbon tax on producers, fails to recycle that tax revenue into any transition assistance for affected consumers, and also omits any public investment in technological innovation. As opposed to a multifaceted package of policies designed to guide the American economy into carbon independence, the WEFA report provides a prime example of testing a single blunt policy tool.

In fact, the WEFA methodology is so infamous that it has merited significant scientific backlash. *The Journal of Commerce* devoted an entire article in (Barrett 1999) to outlining the weaknesses of WEFA's 1998 conclusions regarding implementation of the Kyoto Protocol in the United States. The study "relied upon three critical assumptions, each of which is extremely dubious," writes Barrett (Ibid). WEFA assumed that

1. Prices of renewable energy would not become competitive as fossil energy becomes more costly, and in fact assumed a "rate 27% lower than actual historical experience" showed during the 1973-1985 era of rising energy prices (Ibid); that
2. Renewable technologies would not improve as fossil fuels become more expensive, calculating under a rate that assumes efficiency would respond "43% slower than it did between 1973 and 1985" (Ibid); and finally, that
3. "Virtually no sensible policies will be used to implement the Kyoto Protocol," such as international carbon markets and technology sales to developing countries (Ibid).

While WEFA's 1998 publication may be the "industry standard" for this type of methodology, Barrett and his co-author Hoerner (2002) indicate that other reports in this category include those by EIA (1998), Consad Research Corp. (1998), and Charles River Associates (1997 & 1999). Unfortunately, this study has been unable to explore these further.

3.3b Studies Predicting Continued GDP Growth

Capturing the Energy Opportunity: Creating a Low-Carbon Economy

Pedosta, Stern, Batten
November 2007
(also discussed on pages 31 & 37)

The Center for American Progress reports that the United States Environmental Protection Agency analyzed the potential impacts of the McCain-Lieberman Senate Bill 280, a statute proposed in 2007 to implement a solitary cap-and-trade system absent revenue recycling or transition assistance to affected individuals or corporations. The EPA predicted a GDP consistent with continued growth for S. 280, forecasting that "in the worst case [ratification of S. 280's single blunt tool], GDP in 2030 would be 110.4 percent higher than 2005 rather than 112 percent and that GDP in 2050 would be 234.8 percent higher than 2005 rather than 238 percent higher" (Podosta, Stern, & Batten 2007, 22-24). As the Center for American Progress explains, "understood this way, it is hard to argue that we can't afford to do what it takes to avoid the serious and potentially catastrophic risks of climate change. These and other studies suggest that the cost of making the large changes needed to shift to a low-carbon economy is moderate" (Ibid).

Moreover, the EPA's S. 280 investigations "do not account for complementary policies beyond the basic cap-and-trade program itself. If supporting policies are implemented simultaneously, the modest negative economic effects are reduced or eliminated" (Ibid). With a comprehensive policy package that recycles the revenues of carbon permit sales back into clean-energy development and consumer energy costs, the Center for American Progress projects that post-policy GDP will continue GDP growth parallel to the baseline scenario.

Clean Energy and Jobs: A comprehensive approach to climate change and energy policy

Barrett & Hoerner
2002
(also discussed on page 16)

Barrett and Hoerner defend a balanced methodology better than any other report analyzed in this study. First, they write off studies that examine a single industry yet imply that their sector-specific conclusions will apply economy-wide, such as those sponsored by the United Mine Workers of America, the Bituminous Coal Operators Association, and others 6-7). Secondly, Barrett and Hoerner damningly discount those reports that test a single policy tool implemented in a vacuum at the macro level (Barrett & Hoerner 2002, 6-7). Instead, they propound a well-composed suite of policies for measured macroeconomic gains.

> In contrast to studies that rely exclusively on carbon charges to achieve reductions in emissions, we find that comparable reductions can be achieved when a much more modest carbon charge ($50 per ton as opposed to $100-$300 per ton) is applied in conjunction with policies designed to promote the adoption of energy-efficient technologies. Further, while other studies often predict large economic costs to achieving these reductions (GDP losses in the neighborhood of 0.5-1.5%, with some studies finding losses as high as 3%), the results here find modest macroeconomic gains resulting from this policy set, gains that in the aggregate substantially outweigh the losses forecast for a few sectors (Ibid, 7).

In contrast to the simple microeconomic studies of carbon-cutting policy, Barrett and Hoerner indicate that

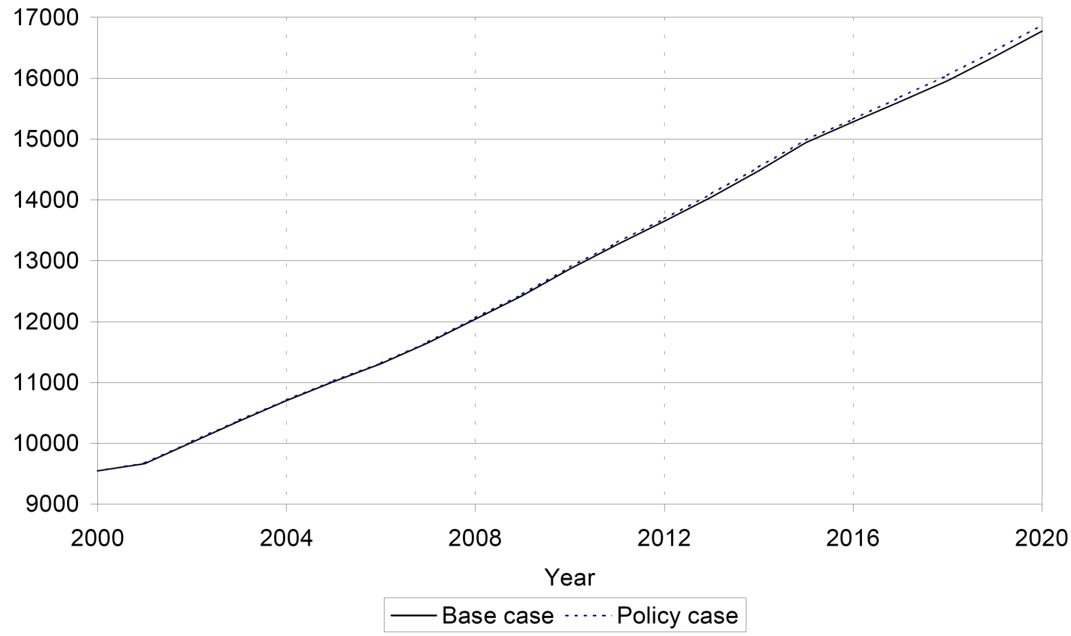
> Our approach in this study is to take the technology forecast from a state-of-the-art bottom-up study, and then use a macroeconometric model to explore the implications of this technology forecast, a carbon charge, and a labor tax cut on the macroeconomic and sector-specific levels. This approach allows us to take advantage of the comprehensive nature of the macroeconometric model without restricting ourselves to its oversimplified technology assumptions. Our results…show a modest improvement in GDP for a moderate energy and carbon efficiency policy (Ibid, 17).

They offer a basic outline for an ideal policy combination.

> The first factor is whether the revenues from a carbon tax or permit system are used to cut other taxes. The economic literature, both theoretical and empirical, is unanimous in concluding that, when the revenues from a carbon charge are used to cut other distorting taxes, the impact of the combined package (carbon charge and tax cut) on GDP is much more positive (or less negative) than for a carbon charge alone…. Depending on the choice of tax cut, economic conditions, model assumptions, and other factors, the net effect of the combined package on GDP may be positive, negative, or zero, but in any case is typically small relative to a policy that relies either on a carbon tax or a grandfathered permit system alone (Ibid, 16).

Overall, Barrett and Hoerner insist that a "combination of revenue recycling and 'no-regrets' technology policy (i.e., policies to promote technologies that pay for themselves over time) accounts for the positive results on GDP and employment" (Ibid, 2). In fact, their GDP predictions are moderately positive, falling within the IPCC's 1996 estimates regarding implementation of Kyoto-level carbon targets, between a 1% gain and 2% loss (Ibid, 15). Specifically, Barrett and Hoerner's policies would increase GDP "by a modest 0.24% in 2010 and by 0.6% in 2020" above the business-as-usual base case" (Ibid, 2).

Figure 2. GDP Growth (billions of 2002 dollars)



Barrett and Hoerner's "policy package results in a small net increase in gross domestic product. GDP increases by 0.2% in 2010 and by 0.6% in 2020, representing $31 billion in 2010 (in 1997 dollars) and $100 billion in 2020. While relatively small, the increase is not insignificant, equaling the gross state product of, say, Montana, Vermont, Wyoming, or South Dakota in 2010, or of Alaska in 2020." (caption: Barrett and Hoerner 2002, p.18; graph: Ibid, p.20, figure 1A)

Table 15.

		Baseline		Policy Scenario		Percent change from baseline	
	2000	**2010**	**2020**	**2010**	**2020**	**2010**	**2020**
GDP (billions of 1997 dollars)	$9,545	$12,863	$16,771	$12,896	$16,878	0.26%	0.64%
Carbon Emissions (millions of metric tons)	1,538	1,814	2,054	1,325	1,018	-26.99%	-50.40%
Total Employment (thousands of jobs)	141,343	154,263	164,119	154,547	165,547	0.42%	0.87%
Manufacturing industries	19,798	19,082	18,210	19,131	18,459	0.26%	1.37%
Coal mining	88	53	46	24	12	-54.14%	-73.91%
Ferrous metals	426	425	354	425	354	-0.08%	0.00%
Service industries	103,849	115,026	123,644	115,835	124,835	0.54%	1.05%

"The increase in jobs is primarily due to higher GDP. Other contributing factors include a slight shift in the pattern of growth toward labor-intensive sectors relative to the baseline." (caption: Barrett and Hoerner 2002, p19; table: Ibid, p19, table 2)

3.3c Comprehensive Growth Studies

Capturing the Energy Opportunity: Creating a Low-Carbon Economy

Pedosta, Stern, & Batten
November 2007
(also discussed on pages 31 & 34)

This study cites the 1970s as a period in which the US greatly improved its energy efficiency while GDP also increased substantially (Podesta, Stern, & Batten 2007, 26). As such, they project that GDP will continue to expand throughout—and very likely *because of*—upcoming investment in energy efficiency across the American economy.

New Energy for America The Apollo Jobs Report: Good Jobs & Energy Independence

Apollo Alliance
January, 2004
(also discussed on page 10)

"Good Jobs and Energy Independence" is among the most comprehensive macroeconomic models testing clean-energy investment, and also one of the most optimistic. In the spirit of President Kennedy's space race, the Alliance recommends a new-generation "Apollo Project," pointing to enormous macroeconomic benefits to be reaped by investing in clean-energy innovation.

Apollo calculates that public investment of $300 billion over ten years will return in $1.4 trillion of new GDP, made up by $953 billion in personal income and $323.9 billion in retail revenues (Apollo 2004, 7) Such optimism notwithstanding, Apollo comments that "the modeling exercise undertaken here assumes a highly conservative level of private-sector investment resulting from federal incentives, and therefore significantly understates potential GDP gains" (Ibid, 20).

A major theme of the Apollo report is that a clean-energy renaissance is an economic opportunity not to be missed:

> The programs embodied in the Apollo Project represent an opportunity to capitalize on multiple markets on the brink of phenomenal growth. Moreover, the research, technologies, products, and methods represent a unique fit in the American economy. They involve higher value-added and, hence, higher-paying employment. These top-quality jobs are necessary to offset the increasing loss of manufacturing jobs in lower technology segments and to create opportunities for a new era of expanding production capacity (Ibid, 32).

Finally, Bezdek lends weight to these conclusions by citing Apollo's conclusions in further reports, including one for the American Solar Energy Society (Bezdek 2007, 13-14) and one printed in the *Journal of Environmental Management* (Bezdek and Wendling 2006).

Fast, Clean, and Cheap: Cutting Global Warming's Gordian Knot

Nordaus & Shellenberger
2007
(also discussed on page 31)

Nordhaus and Shellenberger do not specifically forecast GDP figures, yet they do project significant economic expansion upon public investment in green technology. Furthermore, they too emphasize that studies examining a single carbon-cutting policy typically forecast negative GDP, and reiterate that those studies testing a balanced suite of policies project a future of expanding GDP (Nordhaus & Schellenberger 2007, 24).

3.4 Moving Beyond 'Business as Usual'

Assured of the stable climate that human civilization has heretofore enjoyed, baseline growth forecasts for the American GDP could predict aggressive annual growth in the next half-century. But the costs to GDP by unchecked climate change will in fact injure our economy in the years to come, wasting decades of potential growth. This section has sought to outline academic prognoses for gross domestic product in both "do nothing" and "act now" scenarios. In short, the real dollar costs of not cutting carbon are weighty, and the lost-opportunity costs of not capitalizing upon green expansion would be all the more tragic to bear.

Though these well-founded warnings are gloomy, global warming comes with a striking silver lining. We can counter climate change with comprehensive policy aimed at stimulating investment, job growth and energy efficiency to gain a robust Twenty-first Century economy and national energy security. Not only can we preserve current GDP growth, we can even increase it.

Unfortunately, not all carbon-mitigation policies are created equal. The reports surveyed in this study fall into three categories of methodologies and results:

a. Microeconomic studies presented as macroeconomic analysis, as well as studies that test a single policy tool invariably offer a dire future for the American GDP;
b. Comprehensive studies that predict little GDP variation between baseline scenarios and policy implementation (plus the added dividend of a stabilized climate); and
c. Comprehensive studies projecting considerable growth of the American GDP upon public investment in efficiency and renewable energies.

It is imperative to consider each report's methodology and sponsoring institution in assessing the validity of its conclusions.

4. Consumer Energy Savings

Efficient and renewable energy technology will generate substantial savings for all Americans. The policy options discussed throughout this paper can regulate efficiency measures and aid the commercialization of renewable energy technology, offering savings to individual, corporate, and institutional consumers on their fuel costs and utility bills. According to the Apollo Alliance's 2004 report, these energy savings could amount to $284 billion by 2015 (35). Such savings will liberate capital, cash that would otherwise have been locked into paying for soaring energy expenditures. As such, the positive effects of this climate policy will be exponential, growing as consumers and businesses reinvest their energy savings into the American economy.

Even without including the costs of a destabilized climate, the capital investment required for efficiency and renewables is less than the costs of constructing new fossil-fuel generating capacity (World Bank 2006, 85). If increased energy efficiency is not pursued through policy, the cost of dirty energy generation will rise, as will the cost of energy intensive goods and services. These prices will be passed on to the consumer directly, in the form of higher utility and fuel costs, and indirectly, through price of the energy-intensive goods and services. A comprehensive policy of investment in R&D, deployment and commercialization of clean energy technology, combined with strong mandates for economy wide improvements in energy efficiency will greatly reduce the cost of energy to consumers and producers alike, infusing the economy with much needed savings and stimulating economic growth.

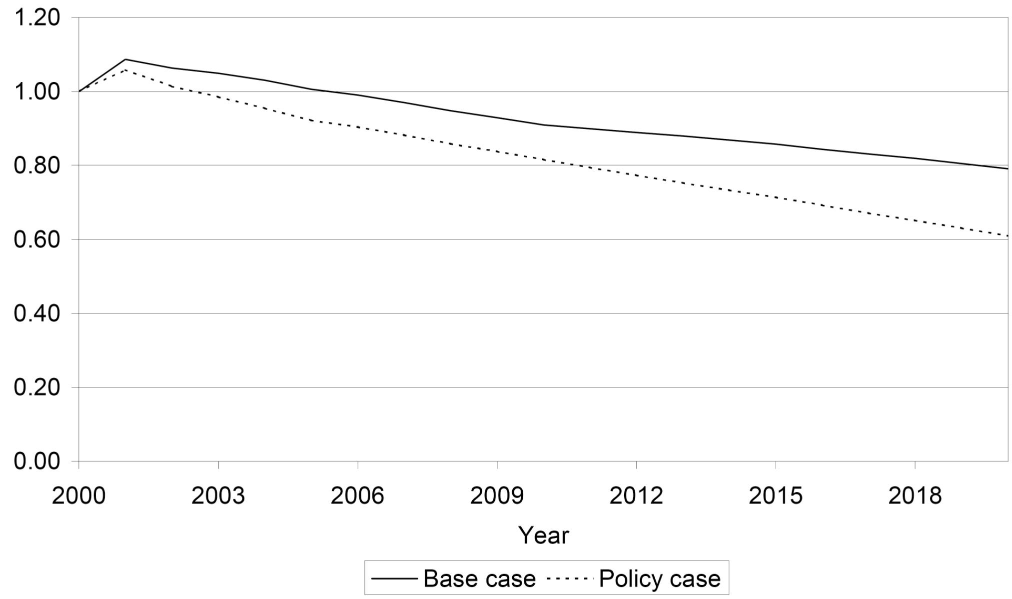
5. Energy Security

5.1 The Future Costs of Energy Dependence

As the United States looks forward into an increasingly globalized and multi-polar world, energy resources figure prominently in the future stability of American power and prosperity. In fact, all resources, from water to arable land, industrial material and intellectual capital are quickly emerging as the focal points of global competition. As these resources become increasingly scarce, they will inevitably become increasingly expensive. There, American dependence on these strategic resources (especially energy) will have profound implications for our continued success.

By boldly confronting climate change, the United States can recast itself as a world leader in low-carbon economic growth, and in doing so free itself from its fatal dependencies on constrained resources. Domestically manufactured sources of clean energy will reduce our dependence on foreign oil, assuring our national security and making energy "more affordable, reliable and less polluting" (Apollo Alliance 2004, 5). Such strategic measures at home will put the United States at the forefront of a geopolitical shift in the global energy landscape.

Figure 3. Oil consumption as a share of GDP (index)



"Under this policy, U.S. dependence on foreign oil declines dramatically relative to the baseline, as does U.S. dependence on oil overall. Under the business-as-usual scenario, oil consumption (crude and net imports of refined products) as a share of GDP falls gradually to about 80% of its 2000 level by 2020." "Under the policy package, this gradual decline is substantially accelerated: by 2020, consumption as a share of GDP has fallen to 60% of its current level, substantially lowering U.S. vulnerability to price shocks on international energy markets." (caption: Barrett and Hoerner 2002, p.23 & 25; graph: Ibid, p.25, figure 7)

5.2 A Declining Dependence on Foreign Oil

This shift will greatly reduce American dependence on dirty fossil fuel resources like oil and coal. With a robust domestic production of clean energy technology, we will reap the economic benefits of technological innovation and a vibrant manufacturing sector. With the proper policies, the United States can transition its energy use away from the wasting entanglements of fossil fuel extraction and importation, and benefit from the internal stability of clean, domestic energy production.

With a comprehensive policy approach in response to climate change, American dependence on foreign oil imports is predicted to decline sharply, as is our dependence on oil overall, with total oil consumption dropping to 80% of its 2000 levels by 2020 (Barrett and Hoerner 2002, 23). The energy use will be replaced primarily through efficiency measures in transportation and building, and through an increased in usage of biofuels and other renewable fuel sources. This substantial decrease in oil consumption is deeply significant for the continued stability of the United States, as it will insulate our economy from price shocks in the global energy market. As these resources become increasingly constrained, price shocks will become more frequent and more severe, damaging those economies that remain dependent on them for continued growth.

5.3 American Clean Energy on the World Stage

By rebuilding our global reputation for technological innovation and intellectual capital, we can develop the clean-energy resources necessary for this crucial shift. The clean-energy technology developed in the United States will enhance our global competitiveness, providing valuable items for exports and reducing our trade deficit, currently a staggering $847 billion (CIA World Factbook) (Apollo Alliance 2004). Global climate change is, as its name implies, a uniquely global problem, and while bold American leadership will certainly accelerate the pace of international cooperation, any truly meaningful reduction in greenhouse gas emissions must be a global reduction. One of the greatest challenges before us is the implementation of low-carbon energy technology in the developing world, especially emerging emissions giants like China, India and Southeast Asia. These growth hungry nations will not sacrifice growth for the sake of climate stability, nor should they be asked to. However, for the developing world to continue its development while achieving deep reductions in its emissions, there will be a great need for affordable clean energy technology. That great need, if met by the technologies developed and produced in the United States will translate into staggering market opportunities and new growth potential for American firms. Not unlike the history of microchips, a product of a Department of Defense project aimed at lowering the per unit cost of microprocessors, clean energy technology could be handed to the private sector and spur a transformational explosion of growth and profit similar to the computer revolution.

Crucially, while fossil fuel resources like oil and coal are found and extracted, often at great economic and political cost, clean energy technology is developed, manufactured and marketed (Sterzinger 2007, 81). Clean energy, then, is produced in the same way that any marketable good is produced, and can be both sold domestically or exported abroad. It is not a commodity, like oil, natural gas or coal that is purchased and burned, slowly depleting a finite supply. Its production generates employment, profit and investment opportunity, while its deployment reduces carbon emissions, mitigating the worst effects of a destabilized climate.

6. Conclusion

The United States has long recognized climate change mitigation as a great challenge to our fossil-fueled economy. A new atmosphere of opportunity and innovation is gaining ground, because the "fossilized" rhetoric of fear and sacrifice is proving to be unfounded.

This study has sought to survey the existing literature that projects the implications of clean-energy policy upon the American economy, with special emphasis upon job creation, gross domestic product, consumer energy savings, and energy security. Our major conclusions are the following:

1. Employment
   - Some industries will be disproportionately affected, and experience significant reductions in employment, however, these sector-specific losses will be more than offset by the economy-wide gains
   - A clean-energy economy can launch millions of new jobs in both blue- and white-collar industries. Depending upon how broadly "green job" is defined, estimates range from a few hundred thousand to 40 million created, with the most reliable research predicting 3 to 6 million.
   - Most importantly, a clean economy will experience net job gains, with lost fossil employment vastly outweighed by new green hiring.

2. Gross Domestic Product
   - Continuing to emit carbon unabatedly into the 21st century, costs to GDP will mount dramatically as we struggle to cope with an unstable climate.
   - Public investment in efficiency and renewable energies will stimulate further private investment in economic expansion, resulting in both national energy security and a robust economy.
   - Not only can these initiatives preserve current American GDP growth, they are likely to increase it.
   - The reports reviewed here fall into three basic categories based on their methodological approach GDP research.
     a. Microeconomic studies presented as macroeconomic analysis as well as studies that test a single policy tool invariably offer a dire future for the American GDP;
     b. Comprehensive studies that predict little GDP variation between baseline scenarios and policy implementation (plus the added dividend of a stabilized climate); and
     c. Comprehensive studies projecting considerable growth of the American GDP upon public investment in efficiency and renewable energies.

3. Consumer Energy Savings
   - Investing now in efficient and renewable energy technology will generate substantial savings for all Americans in the years to come, totaling as much as $284 billion by 2015 (Apollo Alliance 2004, 35).

- The cumulative benefits of wise climate policy will be exponential, growing as consumers and businesses reinvest their energy savings into the American economy.

4. Energy Security
    - In a globalizing world economy, American energy independence is a matter of national sovereignty.
    - A comprehensive policy response to climate change will enable total American oil use to slim to 80% of 2000 levels by 2020 (Barrett and Hoerner 2002, 23). Requiring less oil overall will increasingly relieve us from foreign oil dependency.

Energy strategy that successfully cuts carbon and stimulates the American economy must be a balanced, comprehensive set of policies. A basic framework of that package must include the following:

7. A legally-binding cap-and-trade system that auctions 100% of its carbon permits, and that yearly defines the quantity of those permits according to the emissions reductions targets guided by science;
8. Aggressive federal and private investment framework in R&D, technology deployment, efficiency and job creation;
9. Revenue recycling policies designed to mitigate the impact of the short-term rise in consumer energy prices associated with pricing carbon and stimulating economic growth;
10. Creation of a transitional assistance fund for workers and communities in adversely impacted sectors; and
11. Regulatory increases in efficiency standards for transportation, equipment, appliances, building and land use.
12. Policies preserving the competitiveness of American firms by extending the price of carbon to goods and materials outside of the regulatory jurisdiction of the United States.

Atmospheric carbon concentration and renewable energy have never featured so prominently in American public discourse—from local biodiesel cooperatives to Supreme Court cases, Congressional legislation, and Presidential rhetoric—as they have in the past eighteen months. Furthermore, the current atmosphere of economic uncertainty and a Presidential election promising change in Washington present a unique opportunity for real action against global warming and for a clean-energy transformation.

We hope that this report serves as a resource for policymakers seeking to understand the economic data on which they must ground proactive climate policy. By shifting the focus of the discussion towards the opportunity and positive economic impact of confronting this global challenge, we can reaffirm the creativity, innovation and industry of the American people.

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