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A Green Global Recovery? Assessing US Economic Stimulus and the Prospects for International Coordination

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As the 111th Congress begins and a new president takes office, the economic crisis dominates the US policy agenda. The financial system remains in a tenuous state despite massive bank recapitalization, and the economy, more than a year into the current recession, shows no signs of recovery. Given the scale of the challenge Washington faces and the amount of money required to combat it, there will likely be little room for other legislative priorities. As a result, policymakers are hoping to direct government spending over the next two years in a way that not only generates short-term economic growth and employment but also addresses long-term policy goals sidelined by the current crisis.[1]

Energy and environmental objectives are chief among these goals, as evidenced by the considerable attention given to the notion of a green economic recovery by policymakers and the press. This policy brief provides a framework for evaluating ways to meet energy and climate policy goals as part of an economic recovery effort, assesses a range of policy options currently under consideration, and discusses the prospects for coordinating US actions with those of other major economies for broader effect.

In light of this analysis, we argue that:

- Well-tailored, green components of a recovery effort can create jobs and stimulate the economy while achieving significant energy cost savings for businesses, consumers, and the government. On average, for every billion dollars invested our green recovery scenarios create 30,100 jobs and save the economy $450 million per year in energy costs. These future savings can serve as a sort of "efficiency pay-go" for government outlays today.
- A green stimulus is no replacement for comprehensive climate and energy policy. Even the most aggressive short-term spending will have only a modest impact on US greenhouse gas emissions and dependence on foreign sources of energy. On average, our green policy scenarios reduce annual CO_2 emissions by 592,600 tons for every billion dollars spent. Scaling this investment and focusing funding on programs with the

1. See, for example, President Barack Obama's weekly radio address from January 24, 2009, available at www.whitehouse.gov (accessed on February 2, 2009); Mike Allen, "Pelosi sees bigger, greener stimulus," *Politico.com*, December 12, 2008, available at www.politico.com (accessed on February 2, 2009).

highest return could increase this amount, but would still fall far short of the billions of tons of reductions necessary to stabilize the climate.

- Although green recovery efforts alone will not achieve broader climate and energy objectives, they can reduce the cost of comprehensive climate and energy policy. The most successful programs will be those that can be implemented quickly and can complement, rather than seek to replace, future energy and climate-specific legislation.[2]
- Internationally, the response to the current economic crisis provides an opportunity to lay the foundation for, and build confidence in, a multilateral approach to the climate crisis at the UN-led negotiations in Copenhagen later this year. When G-20 leaders meet in London in April, they should seek to coordinate green components of national stimulus programs and take stock of how these efforts impact long-term emissions reduction goals.

CONTEXT: THE CASE FOR A GREEN ECONOMIC RECOVERY

The push for including energy and environmental programs in an economic recovery effort is driven primarily by two considerations. The first, as mentioned above, is that responding to the current economic crisis will likely monopolize the legislative agenda for at least the first part of 2009. If energy security or climate change (or healthcare or education) policy is not in the cards for President Obama's first 100 days in office, then policymakers would like to see those priorities reflected in an economic recovery package. The second is the view that given the US consumer's new-found propensity to save, direct government investments in infrastructure will provide a more effective stimulus than tax cuts (Zandi 2009).[3] And if infrastructure investment is in order, recent reports argue that more jobs will be created if that investment goes toward renewable energy and mass transit, rather than fossil fuels and road construction (Pollin et al. 2008).

In our view, the logic for a green economic stimulus is a bit different from these political concerns. As demonstrated below, spending even $100 billion on energy and environmental programs as part of an economic recovery package would be far from sufficient to meet energy security and emissions reduction goals. These are long-term challenges that require comprehensive and well-planned energy and climate policy to solve. Because cap-and-trade programs, carbon taxes, or other policies fitting this description are unlikely to take effect until 2013, there is little economic rational for delaying necessary changes to our energy system. The primary value of a green recovery is neither as a substitute for dedicated energy and climate policy, nor as a better driver of jobs growth than the alternative (although some policies would be, as discussed below). Rather, well-designed green components of a recovery effort have the potential to reduce the future cost of such long-term policies and can help to mitigate their impact on the US economy early into its recovery.

Investments in energy efficiency will reduce costs immediately, as cheaper gas and power bills enable households to keep more of their income and the government to offset new debt obligations with lower energy expenditures. To the extent that foregone energy spending is channeled elsewhere in the economy, efficiency investments combine the employment benefits of both building infrastructure and cutting taxes. These benefits continue long after the initial construction work has been completed and make repaying money borrowed to finance the recovery more manageable. Targeted investments in low-carbon energy technology and infrastructure can add to this by making long-term emissions reduction and energy security goals more affordable and achievable.

FRAMEWORK: WHAT ENERGY AND ENVIRONMENTAL PROVISIONS MEET THE TEST?

Energy and environmental investments will only be one component of broader economic recovery efforts. Government spending of the scale currently being considered will necessarily include a broad range of elements, from tax cuts for households and assistance to states to direct government investment in infrastructure, education, and healthcare. Given limited resources, competing demands, and the need to maximize both the economic and environmental benefits of any green component, a framework for assessing possible options is required. In this policy brief we evaluate twelve potential energy-related programs in terms of:

- **Speed**: how quickly the program can be implemented at scale;
- **Jobs**: the number of jobs created directly, in supplier industries, and through paychecks spent in local economies;
- **Energy Prices**: the impact on energy demand and prices both for the program's recipient(s) and the country as a whole;

2. See Trevor Houser, "Structuring a Green Recovery: Evaluating Policy Options for an Economic Stimulus Package," testimony before the House Select Committee on Energy Independence and Global Warming, January 15, 2009, available at www.petersoninstitute.org (accessed on February 2, 2009).

3. See also Douglas W. Elmendorf, "The State of the Economy and Issues in Developing an Effective Policy Response," testimony before the Committee on the Budget, US House of Representatives, January 27, 2009.

- **Energy Security:** reduction in US dependence on imported fossil fuels;[4]
- **Climate Change:** change in CO_2 emissions in both the short and medium terms.

As any energy import and CO_2 emissions reductions achieved from green recovery efforts alone will be modest, we look at how these programs can complement future policy by focusing on:

- **Market Failures:** There are a number of low-cost (or even profitable) opportunities to reduce energy demand and CO_2 emissions through energy efficiency that will likely not respond to price-based climate policy alone. Furthermore, reducing dependence on foreign oil is a policy objective that price-based climate policies will not necessarily address (although price-based energy policies like a gasoline tax could). Targeted government spending can tackle issues that future climate regimes might miss.
- **Technology Hurdles:** Uncertainty about the availability of critical low-carbon energy technology between 2012 and 2030 creates anxiety about the future cost of climate policy. Similarly, high barriers to technological change in transportation make weaning the country off foreign sources of energy an expensive undertaking. Policy adopted today can help accelerate technology development and cut the cost of reducing emissions and oil imports down the road.
- **Infrastructure Bottlenecks:** In addition to reduced costs, the deployment of low-carbon technology and the facilitation of less oil-dependent lifestyles depend on the availability of enabling infrastructure. Whether electricity transmission, CO_2 pipelines, or mass transit, the government will necessarily have a role in building and regulating the infrastructure that facilitates future energy and climate goals. Many of those investments can begin today.

While the green programs evaluated in our study would have a direct impact on US energy demand and carbon emissions, other potential elements of an economic recovery package could do so as well. Money will be spent on improving and expanding roads, bridges, and highways, as well as renewable energy and mass transit infrastructure (Office of the President-Elect 2009). We also evaluate investments that, while not conceived of as energy and environmental programs, would have a meaningful impact on the country's energy and environmental footprint.

SCENARIOS: POTENTIAL GREEN RECOVERY PROGRAMS

The policy scenarios analyzed in this plicy brief are drawn from conversations with policymakers, nongovernmental organizations (NGOs), industry groups, and academics between November 2008 and January 2009 about the types of programs being advocated and considered as part of an economic recovery package. We opted for a representative set of policy proposals rather than an exhaustive list of possible options. Below is a brief description of each.

1. **Household Weatherization:** Install insulation, new windows, and better light bulbs in residential dwellings.
2. **Federal Building Efficiency:** Retrofit federal buildings to reduce overall energy demand.
3. **Green Schools:** Provide funding to ensure that new school construction and renovations of existing facilities are high efficiency.
4. **Production Tax Credit:** Promote the deployment of grid-connected renewable energy through extension of the production tax credit (PTC).
5. **Investment Tax Credit:** Bolster incentives for installing distributed renewable generation options in businesses and households through an increase in the investment tax credit (ITC).
6. **CCS Demonstration Projects:** Fund carbon capture and storage (CCS) demonstration projects around the country.
7. **Cash for Clunkers:** Provide a tax credit toward the purchase of a new or used high-efficiency vehicle when an older and less–fuel efficient vehicle is retired.[5]
8. **Hybrid Tax Credit:** Provide a tax credit toward the purchase of a new hybrid vehicle.
9. **Mass Transit Investment:** Fund "shovel ready" mass transit projects.
10. **Battery R&D:** Fund strategic investment in the research, development, and deployment of advanced battery systems aimed at meeting FreedomCAR goals for reducing cost and weight.[6]

4. Energy security impacts, for the purposes of this analysis, are represented by US dependence on imported fossil fuels. However, this is a fairly limited definition. While it addresses a key political concern—energy imports, particularly imported oil—there are important components of energy security not captured in this narrow definition. A traditional definition of energy security includes not only adequacy of (domestic) supply, but also reliability and affordability. The definition can be further expanded to include the long-term sustainability of energy choices. These considerations are not thoroughly captured in the modeling discussed here, as fossil-fuel dependence is used as a proxy for this broader set of concerns.

5. The term "Cash for Clunkers" does not refer to a specific policy design; our Cash for Clunkers scenario is based on ACEEE (2009). See appendix for a complete description of the methodology used.

6. For information on the US Department of Energy's FreedomCAR program, see Howell (2007).

11. **Smart Metering:** Provide matching funds to upgrade electricity metering, enabling users to better control energy costs and allowing utilities to more effectively manage demand.
12. **Transmission:** Construct high-voltage transmission lines to allow for greater renewable energy penetration.

We tried to construct each scenario in a way that reflected likely policy design while still allowing for flexibility in interpreting the findings. For example, in our production tax credit scenario, we extend the PTC to measure the impact of greater wind deployment on CO_2 emissions and energy prices. Given current economic conditions, policymakers may opt for loan guarantees or grants as an alternative form of incentive. As long as the cost-sharing ratio between government and the private sector remains constant, the findings below should still be applicable. A complete description of the assumptions used to construct each policy scenario can be found in the appendix.

GREEN RECOVERY METRICS

The twelve programs listed above vary considerably in implementation time, impact on the economy and employment, cost certainty, and compatibility with future energy and environmental policy. A qualitative assessment of these green recovery options, relative to each other and to tax cuts and traditional infrastructure investments, can be found in table 1. For a quantitative comparison (table 2), we list job creation, energy savings, emissions cuts, and energy import reductions per billion dollars of government spending. For programs where government dollars are matched by private dollars (such as tax credits, demonstration projects, or some infrastructure investment) we list the ratio of public to private spending.

Figures 1 through 3 depict these results graphically. In figure 2, the horizontal axis indicates reduction in average annual energy expenditures between 2012 and 2020 for the country as a whole, measured in million 2007 US dollars. The vertical axis indicates reduction in average annual CO_2 emissions between 2012 and 2020, measured in thousand metric tons. The size of the bubble reflects the number of direct, indirect, and induced jobs created in the year the money is spent. Figure 3 is similar, but depicts the reduction in net imports of oil (measured in thousand barrels per year) on the horizontal axis and the reduction in net imports of natural gas (measured in million cubic feet per year) on the vertical axis. Circle size again indicates job creation in the program year. Figure 1 compares the number of jobs created while the investment is taking place with the number of jobs created in subsequent years from energy cost savings.

While evaluating the impact of each program per $1 billion spent is useful for comparative purposes, there are limits to how accurately these metrics can be used to estimate the absolute impact of specific spending amounts. The relationship between program size and energy outcomes is not necessarily linear. We modeled most scenarios at the $10 billion level (see appendix), and estimate that results are meaningful for programs between $5 billion and $30 billion. Outside that range, our model would need to be adjusted to reflect actual spending levels in order to provide reliable results.

CREATING JOBS AND LOWERING ENERGY BILLS

With US unemployment rising fast, policymakers' primary goal with any economic recovery effort is job creation. There is considerable uncertainty about the extent to which any stimulus strategy, whether tax cuts or direct government spending, will boost employment in the current economic climate. Our assessment of the jobs potential of green recovery policy options (table 2) is intended for comparison purposes only and not as a predictor of future employment creation. The total number of jobs resulting in practice from any of these programs will depend on specific policy design decisions, the scale and speed with which they are implemented, and current consumer and firm responses to government incentives. We discuss some of these considerations later in this policy brief.

Most of the green policy options we evaluated score fairly well in terms of total job-years created per $1 billion in government spending (or $1 billion in foregone government revenue) relative to nongreen policy alternatives.[7] Both the Congressional Budget Office and leading economists have argued that in light of consumers' current propensity to save, tax rebates will have less of an impact on the economy as a whole, and on job creation in particular, than direct government spending, assuming both occur in the same time period (Zandi 2009).[8] A recent survey of the January 2008 tax rebate recipients supports this analysis, finding that only one-third of the 2008 rebates were spent during that year (Shapiro and Slemrod 2008). Using this assumption and BEA estimates of employment multipliers of household spending, we estimate that 7000 job-years are created for every $1 billion in

7. We measure employment effects in "job-years" or the number of full-time equivalent jobs lasting one year. For example, an investment in building efficiency that created 25,000 jobs-years could mean 25,000 jobs sustained for one year or 5,000 jobs sustained for five years.

8. See also Douglas W. Elmendorf, "The State of the Economy and Issues in Developing an Effective Policy Response," testimony before the Committee on the Budget, US House of Representatives, January 27, 2009.

temporary tax cuts or rebates during the year in which the cuts occur. Permanent tax cuts, or rebates targeted at low-income households, are more likely to be spent and would yield higher job creation. In contrast, spending $1 billion on traditional infrastructure investments (our road construction scenario) would create 25,200 jobs for the year in which the spending occurred. On average, our eleven modeled green scenarios would yield 30,100 jobs for every $1 billion in government spending (table 2).

The relatively high employment intensity of investment in green programs in our model, as compared to traditional infrastructure investments, is the result of two factors. First, tax credit–based scenarios like the PTC extension, the ITC increase, and Cash for Clunkers use public dollars to catalyze private spending. The job creation estimates in table 2 are the total employment effects of the tax credit, not just the share attributable to public dollars. If tax credits spur investment that would otherwise have been delayed, this is an appropriate metric. If the tax credit simply redirects investment from other parts of the economy, then it is the labor intensity of the green investment versus other investment opportunities that is relevant. The same considerations hold for our CCS demonstration project and smart metering scenarios, where public dollars are matched by private spending.

The second factor is the net employment effect of reducing energy costs to the economy as a whole. Since the oil, natural gas, and power generation sectors are less labor-intensive and more import-dependent industries than other sectors, redirecting expenditures from energy to other types of goods and services creates jobs. In our model, we assume that 50 percent of the energy savings to households and firms in the year in which the investment occurs are spent elsewhere in the economy. We therefore add the resulting employment effects to the number of jobs created by the investment itself. This is lower than the savings rate assumed for temporary tax cuts, as analysis suggests that households' marginal propensity to consume is higher when the income change is seen as permanent.[9]

Energy efficiency improvements and price reductions resulting from green recovery efforts have employment benefits that continue beyond the current crisis. While the jobs created by tax cuts and traditional infrastructure investment end once the money is spent, programs that reduce energy costs lead to net employment gains well into the future (figure 1, traditional infrastructure investments and spending on social services like education and healthcare also create important long-term economic benefits but quantitative analysis of these effects is outside the scope of this brief). This helps offset the cost of paying for stimulus spending down the road. For some programs, like retrofitting federal buildings, cost savings flow directly to the government and help offset future debt obligations. And by reducing the energy demand of federal buildings, energy costs decline economy wide. In our model, spending $1 billion on federal retrofits saves the government $130 million a year through improved efficiency and saves the rest of the economy $260 million a year by lowering energy prices. On average, our green recovery scenarios save the economy $450 million per year for every $1 billion invested, a sort of "efficiency pay-go" provision for current government spending.

[P]olicymakers are hoping to direct government spending over the next two years in a way that not only generates short-term economic growth and employment but also addresses long-term policy goals sidelined by the current crisis

ADDRESSING CLIMATE CHANGE

Evaluating the emissions reduction potential of various policy options means balancing short-term benefits with long-term climate policy objectives. For example, of the four transportation scenarios modeled, Cash for Clunkers and battery R&D yield significant emission reductions per government dollar spent, 1.1 million and 1.3 million tons annually per billion government dollars, respectively (table 2 and figure 2). Yet Cash for Clunkers is a one-off policy intervention, with diminishing climate returns over time. The benefits of reducing battery cost and weight, on the other hand, grow exponentially over time, particularly if future climate policy creates incentives for plug-in hybrid adoption. The results of battery R&D, however, are less certain, as our scenario assumes an innovation outcome (i.e., meeting FreedomCAR goals) that may not be possible through $1 billion in government spending.

Among the power-generation scenarios, extension of the production tax credit (PTC) provides the greatest emissions reductions per dollar in the absence of climate policy. Every megawatt of wind power deployed results in a net reduction of 496 tons of CO_2 per year. Spending $1 billion on production

9. See, for example, Douglas W. Elmendorf, "The State of the Economy and Issues in Developing an Effective Policy Response," testimony before the Committee on the Budget, US House of Representatives, January 27, 2009.

tax credits yields 1,466 megawatts of additional wind generation capacity and cuts CO_2 emissions by 727,700 tons per year. Extending the PTC through 2012, as called for in current proposals, would result in an additional 13,400 megawatts of wind and cost tax payers $9.14 billion.[10] But the cost effectiveness of the PTC decreases if a price for carbon is introduced. Extending the PTC through 2012 with a cap-and-trade program taking effect that year (as called for under several proposals from the 110th Congress) would add only 5,800 more megawatts than in a scenario with just a cap-and-trade policy. With the PTC available to all renewable generation, the cost to taxpayers would grow to $24.8 billion and the amount of additional wind capacity per $1 billion in taxpayer dollars would decline to 234 megawatts.

Smart metering investments have more modest emissions benefits in the absence of climate policy or reforms to electricity billing. Installing advanced metering infrastructure (AMI) can help end-users to reduce consumption and utilities to manage demand load. Under a cap-and-trade or carbon tax, the benefits of AMI and other smart-grid technologies increase significantly by facilitating large-scale deployment of plug-in hybrids and renewable energy (Electric Power Research Institute 2008). CCS demonstration projects, on the other hand, only make sense in the context of broader climate policy. Capturing and storing the CO_2 from coal-fired power plants will not be economically efficient in the absence of a carbon price, and thus reducing the cost of CCS technology through demonstration projects is meaningless unless policymakers impose such a price down the road.

Targeted transmission improvements exemplify the type of actions that could address infrastructure bottlenecks that threaten to obstruct other climate and energy goals. While new transmission capacity would have a marginal direct impact on emissions, they have the potential to enable significant reductions through the deployment of renewable sources of power. A recent study by the US Department of Energy (2008a) calls for 12,000 miles of new transmission lines, in concert with policy incentives for renewable energy, to allow wind energy to meet 20 percent of the country's electricity needs by 2030. Although this level of wind generation would reduce annual CO_2 emissions by as much as 225 million tons by 2030, the portion directly attributable to transmission investment is unclear (US DOE 2008a). Since the impact of transmission investment is much harder to quantify, it was not modeled for this policy brief. In addition, the type of intervention that could be undertaken as part of an economic recovery is similarly difficult to identify. Studies by private industry have called for massive levels of grid construction, with cost estimates in the range of $20 billion to $40 billion (American Electric Power 2009). However, addressing some of the regulatory hurdles that have stymied private investment in transmission over the past few decades, including uncertainty over ownership, cost allocation and recovery, state versus federal jurisdiction, and local siting and permitting, may be more important in moving these projects along than additional federal expenditures.

The building efficiency scenarios yield comparatively high emission reductions in and of themselves and complement long-term climate policy by targeting key market failures. Among the efficiency scenarios, providing funding to ensure that new school construction is green yields the largest emission reductions per dollar spent, as efficiency is easier and cheaper to achieve when designing a new building than when retrofitting an old one. Our household weatherization scenario is slightly less cost effective than retrofitting federal buildings because we allocated funding geographically according to past Weatherization Assistance Program spending, rather than where the least-cost opportunities lie from an energy standpoint.

All told, our green policy scenarios (excluding transmission investment and in the absence of climate policy) reduce annual CO_2 emissions by 592,600 tons between 2012 and 2020 for every billion dollars in government spending. This equates to a direct marginal abatement cost of $170 per ton if the reductions persist for one decade and $85 if they persist for two. This is considerably higher than the carbon price estimates for prospective cap-and-trade programs in the United States (EIA 2008c). When the energy cost savings to the economy as a whole resulting from these programs are taken into account, however, the average marginal abatement cost becomes negative.

While the policy options assessed in this policy brief, if well designed and directly targeted, can reduce emissions they are limited in scale. Using the figure for average emission reductions per public dollar spent from above, $100 billion in government funds directed toward energy and environmental programs would cut annual US emissions by 59.3 million tons per year. While significant in absolute terms, this amounts to only 1 percent of total US emissions. Focusing funding on the programs with the highest returns could double this amount, but would still fall far short of the 484 million ton annual reduction that the EIA estimates would result from the Lieberman-Warner Act over the same period (EIA 2008c). Green recovery efforts will only make a meaningful dent in US emissions if they complement comprehensive climate policy.

Balanced against these green policy options are the

10. This cost estimate differs from House and Senate scoring of a PTC extension due to different assumptions about how much capacity will be created in response to the tax credit (United States Senate Committee on Finance 2009).

nongreen programs that will likely be a part of an economic recovery effort. Spending $1 billion on road construction and repair, for example, increases CO_2 emissions by 35,400 tons per year, which cancels out just under half of the emissions reduction gains from spending the same amount on mass transit. If policymakers elected to spend as much on road construction as on a representative basket of green investments, roughly 6 percent of the CO_2 emissions reduction gains from the latter would be cancelled out.

REDUCING DEPENDENCE ON FOREIGN SOURCES OF ENERGY

Freeing the United States from its reliance on foreign oil was a staple theme of the 2008 presidential campaign and has become a rhetorical centerpiece of Washington's current conception of a prospective green recovery. Reducing emissions and bolstering energy security are often seen as two sides of the same coin[11] and policymakers hope that a recovery package can tackle both challenges simultaneously. Yet while our green policy scenarios all yield at least modest emissions reductions, they have more varied impacts on US energy imports (figure 3). And oil is not the only source of energy the United States buys from abroad: 12 percent of natural gas consumption is supplied by imports. National security concerns surrounding gas imports, which come primarily from Canada and Mexico, and oil imports, a large portion of which come from the Middle East, differ considerably. As a result, we have broken down the impact of each scenario on overall US energy imports by fuel type (table 2).

The biggest reduction in natural gas net imports comes from power generation scenarios that replace gas-fired power generation with alternatives. Extending the PTC has the largest impact by using public funds to cover the additional cost of wind power relative to natural gas. Every $1 billion in tax credits spurs the installation of 1,466 megawatts of wind generation and 80 percent of the existing generation displaced when that wind capacity is brought online comes from natural gas. This reduces net gas imports by 5.3 billion cubic feet. CCS demonstration projects also have a meaningful, but more modest impact, as more public money is required for each megawatt installed and only 69 percent of the displaced generation comes from natural gas (10 percent comes from nuclear).

None of the power generation scenarios, however, have much of an impact on US dependence on foreign oil, as oil is no longer commonly used to produce electricity. The only meaningful reductions in US oil imports come from our transportation scenarios. Every $1 billion spent on a Cash for Clunkers program, as defined in our model, reduces net imports of oil by 1.8 million barrels per year. The same amount spent on battery R&D reduces imports by 4 million barrels, assuming that the funding is sufficient to meet FreedomCAR goals. Mass transit investment has a more modest effect in our scenario (which assumes historic allocation of funding by region and mode), as oil consumed by buses offsets some of the gains made by getting vehicles off the road. Providing tax credits for conventional hybrid vehicles has a negligible effect as more than half of the drivers who take advantage of the tax credit would have purchased a hybrid anyway and a significant number of those for whom the credit would change purchase behavior would have otherwise purchased vehicles that can run on ethanol.

On average, our scenarios reduce net imports by 1.8 billion cubic feet of gas and 0.9 million barrels of oil per year for every billion public dollars spent. Spending $100 billion on green programs could have a meaningful impact on US dependence on foreign sources of natural gas, reducing net imports by up to 6 percent, but would have almost no impact on US reliance on foreign oil if not done in conjunction with more aggressive energy security policy. The highest-impact scenario, battery R&D, can only absorb $1 billion, and there are only 11 million vehicles that would qualify for Cash for Clunkers vouchers (ACEEE 2009). Even if all 11 million were traded in, at a cost of $22 billion to the federal government, the program would only reduce oil imports by 39 million barrels per year, less than four days worth of US oil imports. As with efforts to address climate change, the real value of green recovery programs when it comes to improving US energy security is their ability to support long-term policy. Battery R&D, mass transit spending targeted at light rail or bus-rapid transit, and improvements in grid technology will help enable future policy to more effectively and cost-efficiently address energy security concerns.

While the jobs created by tax cuts and traditional infrastructure investment end once the money is spent, programs that reduce energy costs lead to net employment gains well into the future

11. See, for example, Ladislaw et al. (2009).

POLICY DESIGN CONSIDERATIONS

Our assessment of the employment, energy, and environmental benefits of a green economic recovery effort is intended as a theoretical framework for evaluating options and gauging potential results. For comparison purposes, we examine the impact of $1 billion in government spending for each program and assume normal responses to government incentives. In the current economic environment, however, "normal" responses may not occur and policymakers should keep the following considerations in mind when crafting and evaluating a green recovery package.

Speed

The value of government spending in stimulating the economy depends on how quickly the money is put to work. Here our green recovery options vary greatly, both among themselves and compared to the alternatives. The building efficiency scenarios are likely to provide the most immediate stimulus value, as they leverage programs already in existence (the Weatherization Assistance Program or the Federal Energy Management Program) and draw upon a currently underutilized construction industry. Smart meter deployment could also begin fairly quickly, particularly if new meters were installed as buildings are weatherized or retrofitted. Mass transit investments that are already planned and approved could start soon as well.

A Cash for Clunkers program or hybrid tax credit could be implemented rapidly, though it would likely take time for a consumer response to build. Extending the production tax credit would not have much impact until 2010, as the PTC is available until the end of this year, and could even reduce wind investment in 2009 if developers have the option of waiting out the current credit crunch without losing the tax benefit. CCS demonstration projects and battery R&D are much longer-term initiatives, with little new spending likely to occur in either 2009 or 2010, and new transmission investments would likely be modest at first, given regulatory hurdles and uncertainty about future generation mix.

Scale

In addition to the speed at which a program can be implemented, the size to which it can be scaled is an important consideration. As mentioned previously, some scenarios, like battery R&D, require only a few billion dollars at most. The potential scale of programs that rely on tax credits, like Cash for Clunkers, ITC increases, and a PTC extension, depend entirely on consumer and firm response to government incentives and the tax appetite of the market. Given the current retrenchment in private consumption and investment, it is likely that tax credits will prove far less alluring than in a normal economic climate. This is particularly true of the PTC, which depends on businesses and investors having a significant tax burden to reduce in the first place. Given the collapse in profitability across the financial and energy sectors, many renewable projects are having trouble finding developers or external investors with profit margins necessary to absorb a 2.1 cent per kilowatt hour tax credit. A shift to "refundable" credits or direct grants would have the potential to encourage continued renewable deployment despite these economic circumstances. In short, there is considerable uncertainty about the degree to which traditional tax credits will stimulate households and businesses to spend in the absence of other incentives.

Direct government spending on infrastructure investments or on building efficiency projects provide more certainty, but they are not without scale limitations. Only infrastructure projects that are fully planned, have received the necessary approval, and are simply waiting for funding can be expected to start within a timeframe relevant to economic stimulus efforts. For building efficiency programs, the federal agencies that handle household weatherization and federal retrofits have traditionally spent less than $1 billion each year.[12] Channeling billions of dollars toward these projects in a way that yields meaningful economic, energy, and environmental results will require active attention by policymakers and smart government oversight.

Venue

The speed and scale at which prospective green recovery programs can be implemented should not be policymakers' only consideration and the economic recovery effort will almost certainly extend beyond the first legislative package. By all indications, an already lengthy recession is unlikely to ease before the end of the year (IMF 2009).[13] Before then, the US Congress will not only pass an economic stimulus bill, but will also draft new energy and transportation bills and consider federal climate legislation. As Washington works to formulate more comprehensive energy and climate policy in a recession, the Obama administration and the congressional leadership

12. For information on the Weatherization Assistance Program, see US DOE (2008d). For the Federal Energy Management Program, see US DOE (2008b).

13. See also Simon Johnson, "The Global Economy: Outlook, Risks, and the Implications for Policy," testimony before the Senate Budget Committee, January 29, 2009, available at www.petersoninstitute.org (accessed on February 2, 2009).

will need to look for options that meet energy security and emissions reduction goals while at the same time supporting economic recovery. They will need to strike a balance between programs that offer short-term economic gains and those that lay the foundation for longer-term economic strength. And they will need to coordinate domestic actions with those by other major economies around the world and look at how the response to the financial crisis at hand will affect multilateral efforts to prevent a climate crisis down the road.

LOOKING AHEAD AND ABROAD

The G-20 group of developed and developing countries has emerged as the lead forum for orchestrating an international response to the economic crisis. At their meeting last November, G-20 leaders pledged to work together to combat the global recession through coordinated fiscal stimulus. Washington is not alone in looking to meet long-term energy and environmental goals while bolstering short-term economic growth. Japan and South Korea have both trumpeted their stimulus plans as "Green New Deals," China has earmarked much of its $586 billion in spending for energy and environmental projects, and the United Kingdom and Germany have followed suit.[14]

The G-20 will meet again in April to compare notes on the recovery effort and take stock of each country's plan of attack. Leaders will be looking to coordinate their respective stimulus packages to ensure the greatest economic bang for the buck. Given that this same group of countries will be tackling climate change later in the year—either in a small grouping like the Major Economies Process, or through the UN-led negotiations in Copenhagen—they would be wise to assess the cumulative effect of these efforts on global carbon dioxide emissions and work together to ensure that various green stimulus efforts complement each other as well as long-term emissions reduction goals.

Discussion of the energy and environmental components of national recovery efforts provides three benefits:

1. Investments by one country in an emerging low-carbon technology reduce the cost of that technology for everyone. Coordinating government-driven R&D and government-funded demonstration projects can maximize the energy and environmental benefits of every public dollar spent.
2. Efficiency investments that reduce energy demand in one country impact energy prices around the world and thus the cost-benefit analysis used by national policymakers when evaluating domestic programs.
3. The cumulative effects of green recovery programs on national emissions will shape international climate negotiations and the type of commitments that are made as part of a multilateral climate agreement.

Outside of specific green recovery programs, the international response to the global financial crisis overall, and to global economic imbalances in particular, will have a profound effect on the world's energy and environmental trajectory. This is particularly true in the case of the United States and China, without which a solution to either the economic or the climate crisis is not possible.[15] The macroeconomic imbalance between the two countries that emerged over the past decade (excessive US consumption financed by excessive Chinese savings and investment) is reflected in the two countries' carbon footprints. American consumers purchased SUVs and McMansions on the back of cheap credit while Chinese industry overinvested in steel, cement, and aluminum production on the backs of Chinese household savings (Bergsten et al. 2008; Lardy 2008). As a result, more than 70 percent of US CO_2 emissions come from consumer-related activities while more than 70 percent of Chinese emissions come from industry (Rosen and Houser 2007).

The current crisis is already unwinding some of these economic and environmental imbalances. At the close of 2008, US oil demand had fallen 6 percent as consumers tightened their belts, and electricity demand in China was down by 10 percent as energy-intensive industries cut production (EIA 2009b).[16] A smart response to the crisis can perpetuate these trends. Future US consumption will be greener, and the cost of climate policy reduced, if US recovery efforts weatherize homes, upgrade the electricity grid, and help improve automotive fuel efficiency. If China takes advantage of the crisis to consolidate heavy industry, improve its energy efficiency, and free up investment capital for lighter manufacturing and services, then it will emerge from the crisis with a growth model that pollutes less and employs more.

This is not to say that energy and the environment should be a central item on the agenda for the April G-20 meeting in London. The heads of state and finance ministers present will have their hands full shoring up the global financial system and boosting global economic growth. But by discussing the

14. Michael Casey, "UN welcomes Korea, Japan green stimulus plans," *Associated Press*, January 22, 2009; Li Jing, "NDRC: 350b yuan to pour into environment industry," *China Daily*, November 27, 2008, available at www.chinadaily.com.cn (accessed on February 2, 2009).

15. See Trevor Houser, "Finding Agreement on Climate in a Crisis," *Project Syndicate*, December 23, 2008, available at www.petersoninstitute.org (accessed on February 2, 2009).

16. Chinese electricity demand data are from the China Electricity Council via CEIC.

energy and environmental implications of those recovery efforts under consideration and already undertaken, G-20 leaders can help to maximize the value of their domestic green stimulus programs, improve the chances that a global recovery will be sustainable, and build faith in the stability of the global economy and global climate negotiations.[17]

APPENDIX: METHODOLOGY

To assess the energy and environmental impact of our green recovery programs, we used the Energy Information Administration's (EIA) National Energy Modeling System (NEMS).[18] With its extremely detailed model of the energy impacts of US consumer and business behavior both by region of the country and sector of the economy, NEMS is the preeminent tool for forecasting US energy demand and is used to create the Department of Energy's official *Annual Energy Outlook* (AEO). We have modified NEMS to simulate each program included in the study.[19] We modeled our policy scenarios using the just-released AEO 2009 version of NEMS to capture recent changes in policy, energy prices, and technology costs.[20] We also modeled each scenario using the modifications to the NEMS model made last year by the EIA to simulate the impact of the Lieberman-Warner Climate Security Act (S.2191).[21] This allows for an assessment of how programs included in a green recovery package would impact the cost and contours of climate policy down the road.

Our modeling differed from that of the EIA in one respect: We did not use the proprietary macroeconomic module (MAM), which is supplied to EIA by the company Global Insight but is unavailable to the public. Running NEMS with the MAM turned off means that macroeconomic feedback effects from changes in energy supply, demand, and price are not captured. We compared our reference case AEO 2009 forecast without the MAM to EIA's AEO 2009 reference case and found a difference of only 0.01 percent in energy demand in 2020. Given the scope of this difference and the limited size of our policy interventions, we believe that the inclusion of MAM would not meaningfully impact our findings.

It is important to keep in mind that the NEMS model is a tool for understanding possible scenarios, not forecasting definitive outcomes. Energy markets are impacted by myriad elements that are volatile in nature. Each year, changes in energy prices, policy, consumer behavior, and technology costs result in significant revisions to previous *Annual Energy Outlooks*. In addition, each policy scenario was modeled in isolation. In practice, several of the policy options we assessed will likely be adopted in concert, which could change the overall results. Below is an explanation of the changes to NEMS made to assess each scenario, grouped by category.

Building Efficiency

In NEMS, residential and commercial floor space are disaggregated according to census division and building type.[22] To model efficiency improvements in a given number of buildings in a particular group, we increased the efficiency of the group as a whole proportionate to the floor space occupied by buildings actually impacted. For example, to improve the shell efficiency of 5 million single-family homes in New England by 5 percent, we would improve the shell efficiency of the entire stock of 107 million single-family homes in the region by 0.234 percent. This approximation reduces aggregate energy demand by the same amount as improving the efficiency of the 5 million homes in question, and hence yields equivalent effects on energy prices and other related variables.

Household Weatherization

The basis of our household weatherization scenario is past experience from the US Department of Energy's Weatherization Assistance Program.[23] To calculate the energy savings per dollar spent by region from improving air sealing and insulation and installing programmable thermostats (not smart meters), we relied on assessments made by the Oak Ridge National Laboratory (ORNL) and adjusted to present dollars using the Bureau of Labor Statistics' consumer price index (Schweitzer and Eisenberg 2002).

In NEMS, homes are classified by census region and building type and grouped by pre-2006 and post-2005 stock. We improved the shell efficiency of 3.8 million single-family homes of pre-2006 stock to reflect the overall efficiency

17. The UK government has highlighted the need to address the energy and environmental implications of the economic recovery ahead of the London G-20 summit (The London Summit 2009).

18. For documentation on the NEMS, see EIA (2007).

19. The transmission scenario, however, is difficult to model as an independent policy intervention given current NEMS architecture. Instead, we opted for a qualitative discussion of transmission investment based on a review of existing literature.

20. See EIA (2009a). AEO 2009 includes policy changes in the Emergency Economic Stabilization Act of 2008.

21. See EIA (2008c).

22. Homes are classified as single-family, multifamily, and mobile households. Commercial buildings are classified in 11 types (EIA 2008a).

23. For information on the Weatherization Assistance Program, see US DOE (2008d).

improvements resulting from our basket of weatherization measures (per the ORNL study). These weatherization projects were distributed across census divisions based on past Weatherization Assistance Program funding, and our assumptions regarding the average energy efficiency improvement and cost were tailored to the region in which the home is situated. The average cost per home is $1,640, resulting in an overall program cost of $6.2 billion, the amount called for in H.R. 1, the American Recovery and Reinvestment Act of 2009, as of January 26, 2009 (CBO 2009). We assume that all weatherization is completed by the end of 2010.

Federal Building Retrofits

Our underlying estimate of the energy impact of every dollar spent retrofitting federal buildings is drawn from the US Department of Energy's experience with Energy Saving Performance Contracts (ESPCs) under the Federal Energy Management Program (FEMP).[24] FEMP has assessed the energy savings resulting from 195 ESPCs since 1998 and calculates an average energy savings of 8,311 BTU per dollar invested (US DOE 2008c). Based on this, they estimate that reducing the energy demand of all federal buildings by 20 percent would cost $9.4 billion.[25]

We used this as the basis for our modeled scenario. In NEMS, government buildings are treated as commercial buildings and we estimated that federal buildings account for 4.6 percent of total commercial energy use. Based on FEMP's estimates, spending $10 billion on retrofits would reduce energy demand from federal buildings by 83.1 trillion BTU, which equals a reduction in overall commercial energy demand of 0.96 percent. This is the adjustment we make in the model, lowering commercial energy demand by 0.96 percent across building types and regions starting in 2010.

Green School Construction

For this scenario, we improved the energy efficiency of new school construction between 2009 and 2011. Our estimates of the cost of greening new schools and the resulting energy savings were drawn from a Capital E study from October 2006, which evaluated 30 green school construction projects around the country (Kats 2006). The study finds that improving energy efficiency by 33.4 percent adds 1.65 percent to the construction cost. Our estimates of total annual school construction activity and average construction costs are drawn from School Planning and Management's 2008 Annual School Report (Abramson 2008).

We used these estimates, broken down by region, to calculate the marginal cost of making all schools built between 2009 and 2011 green, a total of just under $1 billion. NEMS classifies educational buildings within the commercial module, which allows us to reduce the energy demand by the stock of educational buildings in 2011 to reflect the impact of greening new school construction. We tailored these estimates to each census division, by adjusting the regional definitions in Abramson (2008) to those in NEMS based on school-age population estimates by state from the US Census Bureau's Population Division (2008). This yields an energy efficiency improvement in the total stock of educational buildings of between 0.58 and 2.08 percent depending on census division.

On average, our green recovery scenarios save the economy $450 million per year for every $1 billion invested, a sort of "efficiency pay-go" provision for current government spending

Power Generation

We included five electricity-sector scenarios in this study, four of which we model through NEMS (PTC extension, ITC increase, CCS demonstration projects, and smart metering) and one for which we can only provide a qualitative assessment (the transmission scenario). We provide our methodology on the four modeled scenarios below.

Production Tax Credit (PTC) Extension

NEMS has a dedicated PTC-input variable for each qualifying technology. We extended the PTC at current rates (adjusted annually for inflation) for three years for qualifying renewable energy technologies, which results in extensions through the end of 2012 for wind power and through the end of 2013 for biomass, geothermal, municipal waste, and hydropower. NEMS uses this input to forecast electricity-sector capacity additions, comparing the cost of renewable energy technologies (after accounting for the PTC) with other forms of power

24. For information on FEMP, see US DOE (2008b).

25. Based on authors' correspondence with FEMP analysts, December 22, 2008.

generation.[26]

Investment Tax Credit (ITC) Increase

NEMS also allows for adjustments in the ITC, which allows power producers, businesses, and households to claim a tax credit for a portion of the investment cost of renewable-generation capacity. The Emergency Economic Stabilization Act of 2008 extended the ITC for most technologies through 2016. For our scenario, we increase the percentage of renewable energy investment that qualifies for a tax credit to 45 percent between 2009 and 2012 and remove the dollar limit. After 2012, the ITC returns to existing policy as of December 2008.

Carbon Capture and Storage (CCS) Demonstration Projects

The electricity planning submodule in NEMS allows for the modeling of unplanned capacity additions. Such additions are usually used to force certain electricity generating technologies, such as renewable energy technologies, to meet a power generation mix mandated by policymakers. For our scenario, we added 10 CCS demonstration projects, using integrated gasification combined cycle (IGCC) technology to the unplanned capacity additions to simulate their effect on long-term generation mix, energy prices, and CO_2 emissions. Each plant has a name-plate capacity of 500 MW and our ten projects were geographically dispersed. Given the time required to plan and deploy CCS projects, we assumed a gradual phase-in between 2011 and 2015.

Estimates of the additional cost of installing and operating CCS on an IGCC plant were drawn from a recent report from the Pew Center on Global Climate Change (Kuuskraa 2007). We selected the "high cost" assumptions to reflect an increase in CCS cost estimates since the study was published in 2007.

Smart Metering

The term "smart grid" does not refer to a single technology or policy intervention, but rather to a suite of software, hardware, infrastructure, and business practices. For our scenario, we assessed the impact of deploying advanced metering infrastructure (AMI), a smart metering technology, on residential energy demand. Our cost estimates of installing the household meters, network software, and power distribution hardware as part of AMI deployment were based on a survey of existing AMI initiatives. We found an average cost of $226 per household included in a smart metering initiative.

Our estimates of the electricity savings that result from AMI deployment were drawn from a recent study by the Electric Power Research Institute (EPRI 2008). We adopted EPRI's assumptions of the degree to which AMI facilitates a reduction in line losses and a change in behavior by end-users when deployed to 5 percent of households. We then reduced residential electricity demand in NEMS based on these calculations. A 5 percent residential deployment means installing meters in 5.8 million homes at a cost of $1.3 billion. We assumed 50/50 cost sharing between the public and private sector.

Transportation

We included five transportation scenarios in this study, four of which were green (hybrid tax credit, Cash for Clunkers, battery R&D, and mass transit) and one that was not (road construction).

Hybrid Tax Credit

The Energy Policy Act of 2005 provided tax credits for the first 60,000 hybrid vehicles a manufacturer sells, after which the credit is phased out (IRS 2007). As of January 2009, tax credits have been phased out for Honda, Toyota, and Lexus (Fuel Economy 2009). In our scenario, we raised the tax credit on all hybrid vehicles to $2500 and extended it through 2011, regardless of how many hybrids are sold. We held overall car sales constant to assess the extent to which the credit changes consumers' vehicle preferences and the energy and environmental results of this. The Emergency Economic Stabilization Act of 2008 put in place even larger tax credits for plug-in hybrid vehicles, so we limited our scenario to conventional hybrids.

Cash for Clunkers

Our Cash for Clunkers scenario was modeled on a proposal from the American Council for an Energy-Efficient Economy (ACEEE 2009), which calls for a government rebate of between $1500 and $4500 for drivers who scrap a vehicle with a fuel economy of less than 18 miles per gallon and purchase a new or used vehicle with a fuel economy that is at least 25 percent above current CAFÉ standards. The voucher could also be used for public transportation. Given the way NEMS aggregates the US passenger vehicle fleet and treats consumer preference, modeling this scenario by modifying the NEMS was not feasible. Instead, we adopted ACEEE's assumptions regarding the percentage of drivers who opt to purchase new

26. Electricity capacity planning is a part of the Electricity Market Module of NEMS. For more information, see EIA (2008b).

or used cars or to use public transportation and the resulting improvement in the average fuel economy of the passenger vehicle fleet, with one modification: We assumed that half of the drivers trading in old cars would have purchased a new or used vehicle regardless, based on the experience of Cash for Clunkers programs in California (Dill 2004). For these drivers, we take the difference between the average fuel economy of new vehicles and those that would qualify under the ACEEE's proposal and ascribe this to the program. We calculated the CO_2 emissions and energy import reductions, as well as the energy cost savings, using the AEO 2009 reference-case data to make it consistent with our other scenarios.

The drawback of this approach is that it did not capture the change in energy prices that results from a decrease in demand or the change in energy demand that results from a decrease in prices. As a result, we expect our scenario to slightly overestimate changes in oil imports and CO_2 emissions and to underestimate energy cost savings.

Battery R&D

This scenario differs from the other eleven scenarios in that it assumed a target outcome rather than a specific policy intervention. Our objective was to meet the goals laid out by the US Department of Energy's FreedomCAR program for reducing lithium-ion battery cost and weight.[27] In the AEO 2009 version on NEMS, EIA for the first time fully integrated plug-in hybrid (PHEV) battery cost and weight calculations into the consumer-vehicle choice and manufacturers-technology choice submodules. Their current assumptions are that FreedomCAR will fall far short of meeting its goals. For our scenario, we posited that tripling the program's funding would enable it to reach these goals, and adjusted the battery cost and weight calculations in NEMS to reflect this. This assumption may prove incorrect, and the cost effectiveness of the government spending associated with the program could increase or decrease dramatically.

We used NEMS to calculate the increase in PHEV sales resulting from the battery cost and weight reductions but we did not include the NEMS estimates of the energy and environmental implications of these reductions. This is the first year that the EIA has attempted to comprehensively model the interaction between PHEVs and the electrical grid, and their methodology has not yet been peer reviewed. We chose instead to use estimates of the CO_2 and oil-demand implications of greater PHEV penetration from a recent EPRI study (2007), adjusted for AEO 2009 projections of oil prices, import dependency, vehicle efficiency, and CO_2-intensity of power generation.

As with the Cash for Clunkers scenario, the approach adopted in this scenario did not capture the change in energy prices that results from a decrease in demand or the change in energy demand that results from a decrease in prices. We therefore again expect our scenario to slightly overestimate changes in oil imports and CO_2 emissions and to underestimate energy cost savings.

Mass Transit

To assess the energy and environmental implications of mass transit investment, we started by estimating the impact of government-funded capital investment on passenger-miles travelled. The Federal Transit Administration tracks nationwide investment in and utilization of mass transit through the National Transit Database (2008). The American Public Transportation Association (APTA) compiles key statics from this database each year and makes it available through its *Public Transportation Fact Book* (2008). From this resource, we calculated the ratio between nationwide incremental capital investment and incremental usage in all public transit modes to evaluate the impact of government spending on passenger-miles travelled. We estimated that $10 billion in government spending would be matched by $3.77 billion in private funding for capital projects, and that the combined amount would increase passenger-miles travelled on mass transit by 2.4 percent.

We calculated the corresponding decline in vehicle-miles travelled by car based on a study by ICF International (Bailey 2007). Based on these findings, we made adjustments in NEMS to the passenger-miles travelled by mass transit and vehicle-miles travelled by car, allocated regionally based on current mass-transit utilization. To mirror the methodology used for our road construction scenario (discussed below), we assumed a five-year ramp-up in these effects.

Road Construction

Increases in the quantity and quality of roads have frequently been found to encourage greater growth in vehicle miles traveled (vmt) than would have otherwise occurred.[28] Most of the existing literature has focused on the vmt implications of increases in miles of road lanes. However, even improvements in the quality of highways have been observed to impact driving behavior. The Federal Highway Administration's (FHWA) Highway Economic Requirements System (HERS) is frequently used to evaluate the aggregate impact on the state

27. For information on this program, see Howell (2007).

28. For a review of studies analyzing the relationship between road quality/quantity and vmt, see Litman (2008).

of the US highway system resulting from various capital-expenditure scenarios.[29] The model is uniquely suited to this analysis because it includes travel demand elasticity features that can project driving behavior resulting from modeled changes to the state of the highway system. For this analysis, we relied on exhibits 9-6 and 9-7 from the FHWA's 2004 *Conditions and Performance Report* to correlate vmt and vmt-growth rates with various investment scenarios (US DOT 2004).[30] We used this data to interpolate the vmt impacts of potential capital investments of $30 billion (the amount modeled in this scenario) and used this as the basis to modify NEMS assumptions.

Outside of specific green recovery programs, the international response to the global financial crisis overall, and to global economic imbalances in particular, will have a profound effect on the world's energy and environmental trajectory

It should be noted that HERS optimizes federal spending to fund only the most cost-effective projects at a given expenditure level. As naïve as it may be to think that any federal highway allocations will be spent only on the most cost-effective projects, a massive one-time stimulus may be open to even greater inefficiency. If spending is unable to achieve the road improvements projected by the model, vmt increases would likely be lower than presented here.

Exhibit 9-7 correlates average annual highway spending with projected vmt. However, a stimulus package would be structured as a short-term spike in spending rather than a sustained change to annual expenditures. In this analysis, we assumed that a one-time stimulus of $30 billion would have the same scale of impact as a $1.5 billion increase in average annual expenditures spread over 20 years. However, in order to adjust the timing of vmt impacts to more closely match the funding structure of a fiscal stimulus, we have frontloaded the estimated vmt impacts. In general, the HERS model assumes that 80 percent of vmt impacts will take effect within 5 years, and 100 percent of vmt impacts will take effect within 20 years (Victoria Transport Policy Institute 2008). When modeling a $30 billion stimulus, we assumed that 80 percent of the maximum reductions achieved through a sustained funding change of $1.5 billion per year would occur within the first five years. We assumed that 100 percent of the vmt impacts would have occurred by year 20.

It is likely that at least some of the projects funded through a fiscal stimulus would merely accelerate projects that would have been funded in later years under business-as-usual conditions. It is thus possible that a large stimulus may displace future federal funding for highway maintenance and expansion, thus reducing the vmt impact of a stimulus. However, in order to be consistent with the modeling approach taken in other portions of this analysis, we have chosen to assume that all stimulus spending is entirely additional to business-as-usual expenditures and projects. As a result, this analysis may present a modest overestimate of vmt impacts of a stimulus.

Modeling Employment

To estimate the employment impacts of our green policy scenarios, we relied primarily on RIMS II multipliers from the Bureau of Economic Analysis (BEA 2008). RIMS II allows the estimation of the number of jobs created for one year in a specific industry for every $1 million increase in final demand for that industry's goods and services based on the BEA's national input-output data. We used 2006 multipliers, which are only available at a 60-industry aggregate level. The drawback of this approach is that all utilities are aggregated as one industry, which does not allow for a comparison of the net employment effects of switching between types of power generation.[31]

To address this, we relied on the National Renewable Energy Laboratory's (NREL) JEDI database to calculate the employment effects of the energy results from the NEMS analysis. JEDI uses a "bill-of-goods" approach to input-output based employment multipliers and is updated regularly to reflect actual project-development costs and labor-content requirements (NREL 2009). JEDI provides estimates for coal, wind, natural gas, ethanol, and concentrated solar thermal generation. For solar photovoltaic and biomass, we relied on a study from the Renewable Energy Policy Project (Singh and Fehrs 2001). For nuclear power, we relied on a Nuclear Energy Institute (2008)

29. For a description of the HERS model, see FHWA (2008).

30. In its 2006 *Conditions and Performance Report*, the FHWA adjusted HERS to reflect the assumption that highway expenditures are funded through levies imposed on drivers (e.g., gas taxes). As a result, increases in vmt resulting from improved roads are partially offset through increases in direct costs associated with driving on those roads. Since a fiscal stimulus would probably not be funded through such levies, we have sourced all data from the 2004 *Conditions and Performance Report*, rather than the more recent 2006 report.

31. See Kammen, Kapadia, and Fripp (2004) for a good discussion of the methodological challenges in assessing the labor impacts of energy policy changes.

assessment of the North Anna Power Station.

In estimating the employment effects of energy cost savings to households, we used the RIMS II multipliers for household consumption. For energy savings that occur during the first three years of the program, we assumed that 50 percent would be spent and the rest saved. Longer-term, we assumed that whatever is saved ultimately is put to work in the economy through investment, which we assumed has the same employment multiplier as household expenditures.[32] Balanced against these employment gains are the corresponding losses in the energy sector from foregone revenue. We calculated these using JEDI and the other input-output based energy-sector employment studies mentioned above.

32. For a good background discussion of the employment effects of energy efficiency, see Scott, Roop, and Shultz (2002); Scott et al. (2004); and Roland-Holst (2008).

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Table 1 Green recovery matrix—assessing employment, energy security, and environmental impacts per $1 billion in government spending

	Speed of implementation	Employment	Energy savings	Energy security	Climate change			
Green programs		Job -years created	Long-term energy cost reductions	Reduction in US oil imports	Direct emissions reductions	Market failures	Technology hurdles	Infrastructure bottlenecks
Household weatherization	High	Moderate	Low	Moderate	Moderate	High		
Federal building retrofits	High	Moderate	Moderate	Very low	Moderate	High		
Green school construction	Moderate	Moderate	High	Very low	High	High		
PTC extension	Low	High	High	Low	High		Low	
ITC increase	Low	High	Low	Very low	Low		Low	
CCS demonstration projects	Very low	Moderate	Low	Very low	Moderate		High	
Cash for clunkers	Moderate	Very high	Moderate	Moderate	High	Moderate		
Hybrid tax credit	Moderate	Low	Very low	Very low	Very low	Low		
Battery R&D	Very low	Moderate	Very high	Very high	Very high		High	
Mass transit	High	High	Very low	Moderate	Very low	Low		Low
Smart metering	Moderate	High	Very high	Low	Low		Moderate	Low
Transmission	Very low	n.a.	n.a.	n.a.	n.a.		Low	High
Other programs								
Tax cuts*	Very high	Very low	–	–	–			
Road investment	High	Moderate	Negative	Negative	Negative			

n.a. = not applicable

* Tax cut job estimates assume that 35 percent of the income returned to households will be spent that year.

Table 2 Green recovery by the numbers—impact of $1 billion in government spending relative to the AEO 2009 reference case

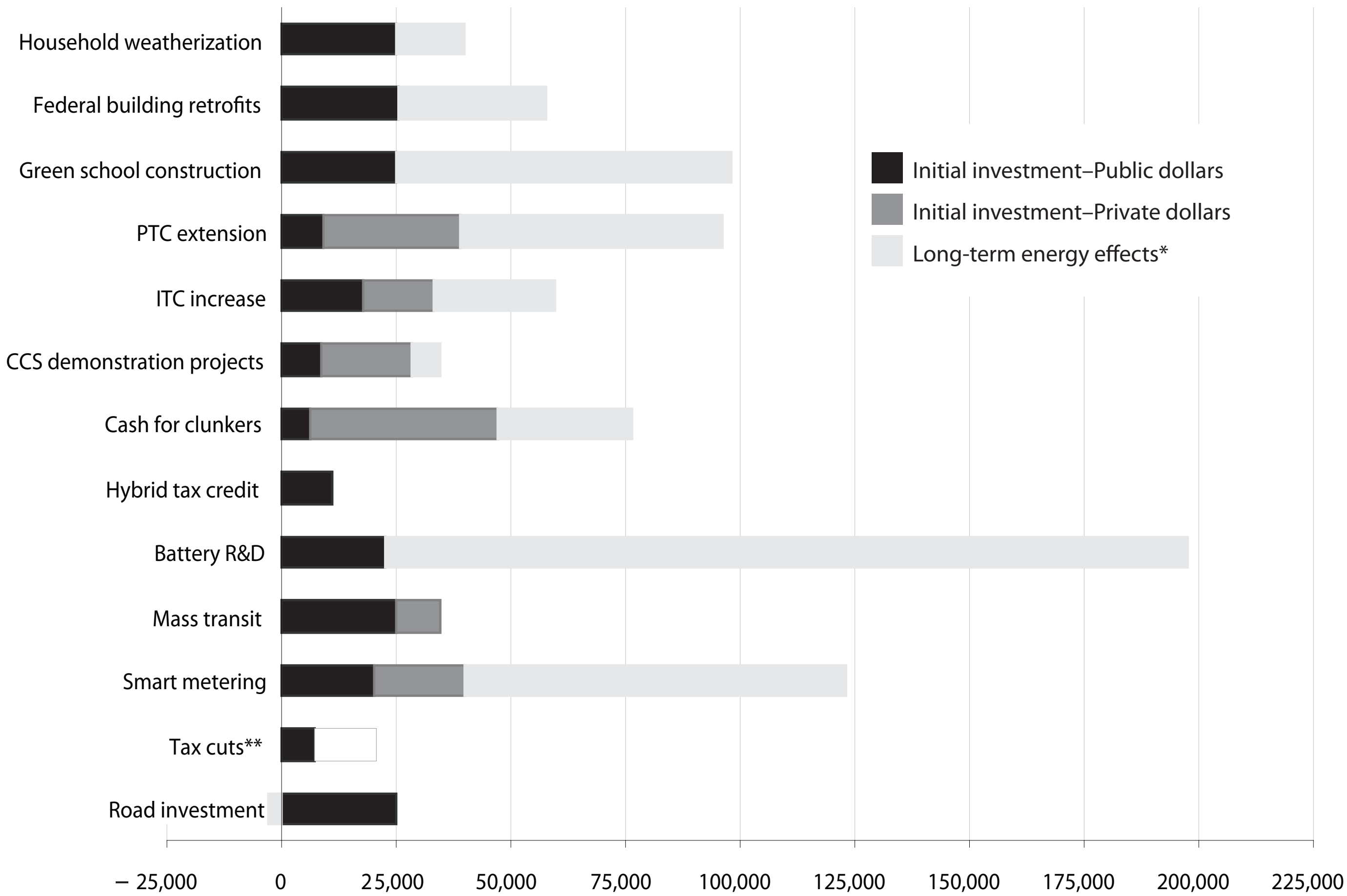
	Employment[1]	Energy costs[2]	CO_2 emissions[3]	Oil imports[4]	Gas imports[4]	Private share[5]
Green programs	**Job-years**	**Millions of US dollars/year**	**Thousand tons/year**	**Thousand barrels/year**	**Million cubic feet/year**	**Percent of total**
Household weatherization	25,100	207.8	440.7	197.7	1,473.7	0.0
Federal building retrofits	25,300	386.7	546.9	–	1,431.5	0.0
Green school construction	25,200	609.2	905.8	–	663.8	0.0
PTC extension	39,100	562.5	727.7	107.0	5,313.1	76.1
ITC increase	33,300	208.7	213.4	21.8	1,072.4	47.0
CCS demonstration projects	28,500	225.3	341.6	–	2,804.9	68.8
Cash for clunkers	46,900	433.0	1,112.5	1,784.6	–	86.8
Hybrid tax credit	11,100	–	–	–	–	0.0
Battery R&D	22,500	1,278.8	1,332.8	4,059.6	–	0.0
Mass transit	34,500	23.6	87.3	175.1	–	27.4
Smart metering	40,000	918.0	207.4	78.8	127.1	50.0
Transmission	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Other programs						
Tax cuts[6]	7,000	n.a.	n.a.	n.a.	n.a.	n.a.
Road investment[7]	25,000	(32.8)	(35.4)	(87.1)	–	0.0

1. Employment numbers are measured as the total number of direct, indirect, and induced jobs created by $1 billion in government spending during the year in which the spending occurs. This includes jobs lost in the energy sector as the result of improved efficiency and those gained when energy savings are spent elsewhere in the economy, but not jobs lost as a result of higher tax rates to recoup the fiscal cost of green stimulus programs. Figures include jobs attributable directly to public spending versus the jobs created by private spending that the program generates. Job estimates for changes in electricity generation capacity assume 100 percent domestic content for materials and technology.
2. Average annual reduction in energy expenditures for the economy as a whole between 2012 and 2020.
3. Average annual reduction in CO_2 emissions between 2012 and 2020.
4. Average annual reduction in net imports between 2012 and 2020.
5. Indicates the share of jobs, energy savings, CO_2 emission reductions, and oil and gas import reductions resulting from private spending related to each program catalyzed by $1 billion in public expenditure. Rather than being financed by public debt, as is the case for the government outlays, private spending resulting from a specific program is either redirected from private savings or other private expenditures.
6. Tax cut job estimates assume that 35 percent of the income returned to households will be spent that year.
7. Figures for energy costs, CO_2 emissions, and oil imports are net increases, not reductions.

n.a. = not applicable

AEO 2009 = US Department of Energy, *Annual Energy Outlook*, 2009.

Figure 1 Total employment effects—job-years created through $1 billion in government investment



* Long-term energy effects measures the net change in employment (measured in job-years) resulting from energy savings and the change in energy mix for the decade following the initial investment.

** For tax cuts, the lighter field indicates the employment effects of the share of the intitial tax cut or rebate saved until future years.

Figure 2 **Economic and environmental impact of recovery policy options—reduction in annual energy expenditures (X-axis), CO_2 emissions (Y-axis), and job creation (circle size) for every $1 billion spent**

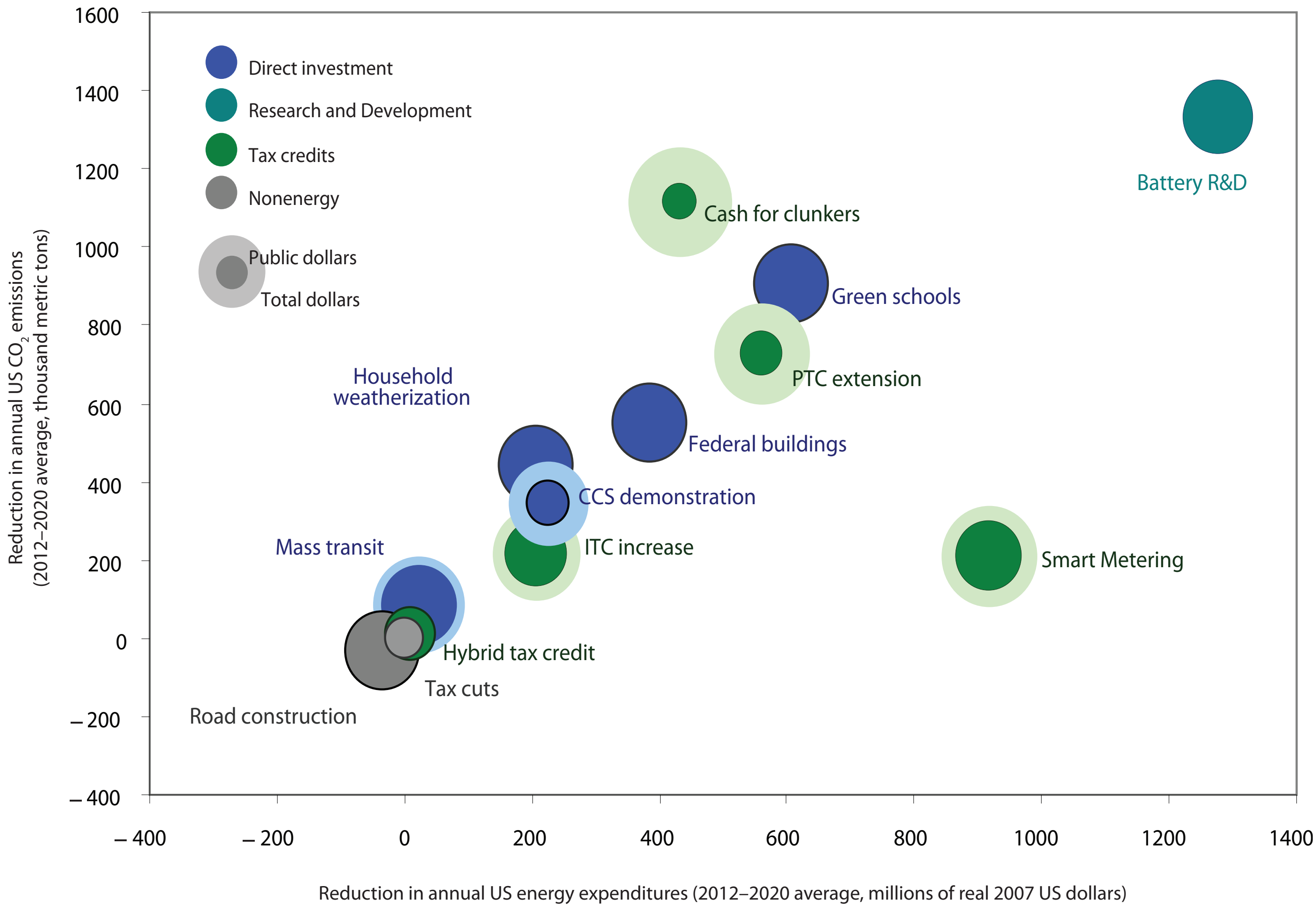


Figure 3 Economic and energy security impact of recovery policy options—reduction in annual oil imports (X-axis), natural gas imports (Y-axis), and job creation (circle size) for every $1 billion spent