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Individual Carbon Emissions: The Low-Hanging Fruit

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INDIVIDUAL CARBON EMISSIONS: THE LOW-HANGING FRUIT

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The individual and household sector generates roughly 30 to 40 percent of U.S. greenhouse gas emissions and is a potential source of prompt and large emissions reductions. Yet the assumption that only extensive government regulation will generate substantial reductions from the sector is a barrier to change, particularly in a political environment hostile to regulation. This Article demonstrates that prompt and large reductions can be achieved without relying predominantly on regulatory measures. The Article identifies seven "low-hanging fruit:" actions that have the potential to achieve large reductions at less than half the cost of the leading current federal legislation, require limited up-front government expenditures, generate net savings for the individual, and do not confront other barriers. The seven actions discussed in this Article not only meet these criteria, but also will generate roughly 150 million tons in emissions reductions and several billion dollars in net social savings. The Article concludes that the actions identified here are only a beginning, and it identifies changes that will be necessary by policymakers and academicians if these and other low-hanging fruit are to be picked.

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INTRODUCTION

An emerging consensus suggests that reducing the risks of catastrophic climate change will require leveling off greenhouse gas emissions in the near term and reductions of 60 to 80 percent from present levels by 2050.[1] Reductions at these levels are all the more daunting in the face of projections

1. *See* Michael P. Vandenbergh & Anne K. Steinemann, *The Carbon-Neutral Individual*, 82 N.Y.U. L. REV. 1673, 1675 (2007). Entities that have adopted such targets include roughly two dozen corporations that are members of the U.S. Climate Action Partnership. *See, e.g.*, U.S. CLIMATE ACTION PARTNERSHIP, A CALL FOR ACTION: CONSENSUS PRINCIPLES AND RECOMMENDATIONS FROM THE U.S. CLIMATE ACTION PARTNERSHIP: A BUSINESS AND NGO PARTNERSHIP 3–7 (2007), *available at* http://us-cap.org/USCAPCallForAction.pdf (setting short- and long-term goals); Immediate Actions to Reduce Greenhouse Gas Emissions Within Florida, Exec. Order No. 07-127 (2007), *available at* http://www.flgov.com/pdfs/orders/07-127-emissions.pdf (setting a long-term goal of 80 percent reductions from 1990 levels by 2050).

that global emissions will grow by roughly 50 percent by 2030[2] and double by 2050.[3] If the consensus about the speed and magnitude of the required emissions reductions proves to be accurate, the public and private response cannot afford to overlook any major sources. Doing so will increase the costs of emissions reductions and may make it impossible to achieve short- and long-term targets.

This Article demonstrates that the individual and household sector represents an enormous and largely untapped source of prompt, low-cost emissions reductions. Carbon dioxide (CO_2) is by far the most important greenhouse gas,[4] and recent scholarship has demonstrated that individual and household emissions comprise roughly 30 to 40 percent of the CO_2 emissions from the United States.[5] In theory, the individual and household sector thus represents a major target of opportunity for policymakers.

Despite the potential for large, low-cost reductions from the individual and household sector, most federal, state, and local climate change measures focus directly on large industrial sources and will reduce individual and household emissions only indirectly. For example, the leading cap-and-trade legislation in Congress includes a 10,000 metric ton threshold—orders of magnitude higher than the several tons per year emitted by the average U.S. household.[6] Regional and state trading programs have adopted or proposed similar regulatory and reporting thresholds.[7] These downstream cap-and-trade programs (for example, caps on emissions from electric generating facilities) will reduce emissions from individuals and households indirectly by increasing the price of energy and consumer goods.[8] Similarly, upstream

2. *See* ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, INTERNATIONAL ENERGY OUTLOOK 2007, at 5 (May 2007), *available at* http://eia.doe.gov/oiaf/archive/ieo07/pdf/0484(2007).pdf (projecting a 57 percent increase in global emissions in 2030) [hereinafter EIA, OUTLOOK 2007].

3. *See* Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years With Current Technologies*, 305 SCIENCE 968, 968–69 (2004) (projecting an increase from seven to fourteen gigatons of carbon between 2004 and 2054).

4. EIA, OUTLOOK 2007, *supra* note 2, at 14.

5. *See* discussion *infra* notes 34–38 and accompanying text.

6. *See* America's Climate Security Act of 2007, S. 2191, 110th Cong. §§ 4(7), 1102(1) (introduced by Sens. Lieberman and Warner) (defining "covered facilities" and "affected facilities"). This legislation defines carbon dioxide equivalents to mean "the quantity of the greenhouse gas that the Administrator determines makes the same contribution to global warming as 1 metric ton of carbon dioxide." *Id.* § 1(4); *see also* Vandenbergh & Steinemann, *supra* note 1, at 1692–94 (finding that individuals on average accounted for over 14,000 pounds of carbon dioxide (CO_2) emissions in 2000).

7. *See, e.g.*, Nancy Netherton, *Washington State Agencies Recommend Strategies to Reduce Greenhouse Emissions*, DAILY ENV'T, Dec. 31, 2007, at A-6 (noting new Washington regulations proposing a 25,000 metric ton threshold for greenhouse gas emissions reporting).

8. *See* CONG. BUDGET OFFICE, ECONOMIC AND BUDGET ISSUE BRIEF, TRADE-OFFS IN ALLOCATING ALLOWANCES FOR CO_2 EMISSIONS 1 (Apr. 25, 2007), *available at* http://www.cbo.gov/ftpdocs/80xx/doc8027/04-25-Cap-Trade.pdf.

cap-and-trade programs (for example, caps on fossil fuel imports and extraction) also will reduce individual and household emissions indirectly by increasing prices.[9] Efficiency standards imposed on the manufacturers of motor vehicles, appliances, and other consumer goods also will reduce emissions from consumers who buy the more efficient goods.[10]

Although these indirect measures will reduce individual and household emissions, they will leave enormous potential reductions on the table. To illustrate, cap-and-trade-based increases in energy prices will influence behavior, but research suggests that large price increases may be necessary to induce meaningful reductions in energy consumption.[11] Further, recent increases in gas prices have had modest effects on behavior,[12] and "energy invisibility" and other constraints limit household responses to electricity price increases.[13] Efficiency mandates bypass these shortcomings to some extent, but the potential for emissions reductions from efficiency mandates is limited by the extent to which industry lobbying blocks or delays the mandates and by the extent to which consumers opt for more efficient goods.[14]

If individuals and households comprise a third or more of all emissions, and indirect measures leave emissions reductions on the table, why do so few policies target these emissions directly? One possibility is the widespread

9. Upstream cap-and-trade schemes regulate the importation or production of the regulated substance, whereas downstream schemes regulate the entities that release the regulated substance. *See* America's Climate Security Act of 2007 § 4(7)(A), (B).

10. *See, e.g.*, Average Fuel Economy Standards for Light Trucks Model Years 2008–2011, 71 Fed. Reg. 17,566 (Apr. 6, 2006) (to be codified at 49 C.F.R. pts. 523, 533, 537) (mandating increased fuel economy for motor vehicles); Central Air Conditioners and Heat Pumps Energy Conservation Standards, 10 C.F.R. § 430 (2007) (mandating increased efficiency for air conditioners and heat pumps).

11. *See* Paul C. Stern, *Information, Incentives, and Proenvironmental Consumer Behavior*, 22 J. CONSUMER POL'Y 461, 469 (1999). *See generally* NAT'L RESEARCH COUNCIL, ENERGY EFFICIENCY IN BUILDINGS: BEHAVIORAL ISSUES 9–10, 40 (Paul C. Stern ed., 1985) [hereinafter NRC, BEHAVIORAL ISSUES] (discussing influences on energy efficiency behaviors).

12. *See* Ana Campoy, *Americans Start to Curb Their Thirst for Gasoline*, WALL ST. J., Mar. 3, 2008, at A-1; Jonathan E. Hughes et al., *Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand* (Nat'l Bureau of Econ. Research, Working Paper No. UCD-ITS-RR-06-16, 2006), *available at* http://pubs.its.ucdavis.edu/publication_detail.php?id=1050.

13. "Energy invisibility" refers to the absence of awareness of the sources of residential energy consumption. *See* NAT'L RESEARCH COUNCIL, ENERGY USE: THE HUMAN DIMENSION 36–42 (Paul C. Stern & Elliot Aronson eds., 1984) [hereinafter NRC, HUMAN DIMENSION].

14. *See, e.g.*, Christopher Conkey & Stephen Power, *Lobbyists Push for Sway Over Fuel-Economy Rules*, WALL ST. J., July 2, 2008, at A9 (noting auto maker lobbying against stringent fuel-economy rules). Steep discount rates and similar phenomena reduce consumer uptake of many energy efficient goods. *See* NAT'L RESEARCH COUNCIL, DECISION MAKING FOR THE ENVIRONMENT: SOCIAL AND BEHAVIORAL SCIENCE RESEARCH PRIORITIES 78–81 (Garry D. Brewer & Paul C. Stern eds., 2005) [hereinafter NRC, DECISION MAKING]. In addition, roughly one-sixth of the population may lack the financial resources needed to take advantage of many efficient goods that require large up-front expenditures. *See* Michael P. Vandenbergh & Brooke Ackerly, *Climate Change: The Equity Problem*, 26 VA. ENVTL. L.J. 53, 61 (2008).

belief that only extensive government regulation will generate large, prompt reductions in individual and household emissions.[15] If extensive government regulation is required, the lack of political support for such measures makes direct emissions reductions from individuals and households a nonstarter in the current political environment.[16]

In this Article, we challenge the view that only extensive government regulation will generate prompt, large emissions reductions from individuals and households. We focus on one of the most important potential reasons why policymakers at the federal, state, and local levels may be directing laws and policies in other directions: a lack of awareness of the emissions reductions that are available at levels of political and economic cost that compare favorably to those of measures directed at other sources. We argue that information provision may be an effective and politically viable measure to reduce individual and household emissions in some cases, and in other cases combinations of information provision, economic incentives, and modest legal requirements may succeed, even in the antiregulatory environment prevailing in the United States.[17] Although in this Article we focus on the extent to which individual and household emissions represent low-hanging fruit in the United States, we note that these opportunities are global. Individuals and households comprise comparable shares of national emissions in other developed countries,[18] and a recent report concludes that

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15. *See, e.g.*, Ann E. Carlson, *Only by Requiring Lifestyle Change, Not Suggesting It*, 24 ENVTL. F. 48 (2007) (stating that "individuals and households will not achieve substantial, near term reductions in greenhouse gas emissions absent extensive government regulation").

16. Despite the drumbeat of media reports warning of arctic ice loss, *see, e.g.*, *'Arctic is Screaming' Scientists Say: Quickened Melting Threatens Sea Ice*, TENNESSEAN, Dec. 12, 2007, at 1A (noting a recent projection that summer time arctic sea ice may disappear by 2013), and other indicators that climate change is accelerating, public support for regulation of individual behavior is lacking. Recent polling suggests generalized concern about climate change, but it ranks seventh among voters' priorities, well behind competing concerns such as high gas prices and economic growth. *See* Hart/Newhouse Research Companies, Study No. 6073 (June 2007), *available at* http://online.wsj.com/public/resources/documents/0607-wsj-nbc-polldoc_6pm.rtf.pdf (discussing findings of a survey conducted on behalf of NBC News and the Wall Street Journal based on telephone interviews with a national adult sample of 1,008). Efforts to regulate individual behavior directly have been rare, perhaps because past efforts such as lowering speed limits have generated a swift, ferocious response. *See, e.g.*, Michael P. Vandenbergh, *From Smokestack to SUV: The Individual as Regulated Entity in the New Era of Environmental Law*, 57 VAND. L. REV. 515, 555–56 (2004) (noting the public response both to speed limit reductions in Texas as well as ozone precursor emissions from backyard grilling in California).

17. *See generally* Editorial, *T.R.? He's No T.R.*, N.Y. TIMES, Feb. 11, 2007, at 4.11.

18. *See, e.g.*, ENVT. AUDIT COMM., U.K. HOUSE OF COMMONS, PERSONAL CARBON TRADING: FIFTH REPORT OF SESSION 2007–08, at 8–9 (2008), *available at* http://www.publications.parliament.uk/pa/cm200708/cmselect/cmenvaud/565/565.pdf (noting the importance of household emissions in the United Kingdom and that the household share accounts for roughly 40 percent of its carbon emissions); *see also U.K. Enviro Minister Backs Personal Carbon Quotas*, GREENWIRE,

residential emissions may represent one of the top two global opportunities for low-cost CO_2 emissions reductions.[19]

After briefly identifying the criteria for emissions reductions measures to serve as a viable addition to the current policy mix, we examine seven potential low-hanging fruit reductions. These are by no means all of the low-hanging fruit opportunities, but these seven actions have the potential to generate prompt, large reductions at lower cost than many of the measures adopted or proposed to date. They further serve as examples of the types of additional measures that an intensive research and policy effort could identify and address.[20]

We demonstrate that viable measures directed at these emissions sources can generate large emissions reductions quickly and cheaply. In fact, if started in 2009 the limited set of low-hanging fruit measures outlined in this Article can reasonably be expected to generate a reduction in annual emissions in the neighborhood of 150 million short tons of CO_2 by 2014.[21] The magnitude of this reduction compares favorably to a number of benchmarks, both in terms of the volume and the speed by which the reductions can be accomplished. For example, these reductions constitute 47.7 percent of the annual CO_2 now emitted by petroleum refiners in the United States and almost three times the annual CO_2 emissions by the aluminum industry.[22] Put another way, these savings are the equivalent of removing 26 million automobiles from the road or eliminating the need for 54 large power plants.[23] The low-hanging fruit emissions reductions also

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July 20, 2006, http://www.eenews.net/Greenwire/print/2006/07/20/9 (noting that the share comprised by the individual and household emissions sector in the United Kingdom is 44 percent).

19. *See* FLORIAN BRESSAND ET AL., MCKINSEY GLOBAL INST., CURBING GLOBAL ENERGY DEMAND GROWTH: THE ENERGY PRODUCTIVITY OPPORTUNITY 57 (2007).

20. For this analysis, we focus on emissions from those behaviors that are under the substantial, direct control of individuals and thus may be most affected by laws and policies targeted at this source category. *See* Paul C. Stern et al., *Strategies for Setting Research Priorities*, *in* NAT'L RESEARCH COUNCIL, ENVIRONMENTALLY SIGNIFICANT CONSUMPTION: RESEARCH DIRECTIONS 124, 133 (Paul C. Stern et al. eds., 1997) (concluding that "[o]ne useful strategy is to begin with possible policy interventions" when analyzing the sources of pollution).

21. *See infra* note 64.

22. MARK SCHIPPER, ENERGY INFO. ADMIN, NO. DOE/EIA-0573, ENERGY-RELATED CARBON DIOXIDE EMISSIONS IN U.S. MANUFACTURING 4 tbl.1 (2005).

23. The average automobile in the U.S. emits 11,470 pounds of CO_2 or 5.735 tons per year. *See* ENVTL. PROT. AGENCY, UNIT CONVERSIONS, EMISSIONS FACTORS, AND OTHER REFERENCE DATA 6 (2004) [hereinafter, EPA, UNIT CONVERSIONS]. Dividing the projected savings of 150 million tons by 5.735 tons per year yields roughly 26 million vehicles. Further, the average power plant emits 0.696 tons of CO_2 per megawatt hour. *Id.* at 7. On average, it supplies 4 million megawatt hours per year. *Id.* Hence, on an annual basis it emits 2.784 million tons of CO_2. Dividing 2.784 million ton total into 150 million tons yields 54 power plants. There are nearly 500

could constitute a large portion of one of the global "stabilization wedges" proposed by Pacala and Socolow.[24] They could account for more than half of the 2012 emissions reductions required by the leading federal legislative proposal (the Lieberman-Warner Climate Security Act)[25] and for 75 percent of the 2020 emissions reductions projected to be achieved by the new Corporate Average Fuel Economy (CAFE) standards in the Energy Independence & Security Act of 2007.[26]

In addition to large, prompt reductions, the low-hanging fruit measures have the prospect of achieving these reductions at far lower cost than the average per-ton carbon reduction cost of leading proposed measures. For example, a recent estimate of the marginal cost of the Lieberman-Warner Bill is roughly $20 per ton in 2015, increasing to over $100 per ton by 2050.[27] In contrast, although we have not attempted to conduct a thorough cost analysis, the low-hanging fruit measures all have a reasonable prospect of generating net negative abatement costs—social *savings*, not costs—in

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major power plants (those that generate at least 2 million megawatt hours of electricity annually) in the U.S. Energy Info. Admin., U.S. Dep't of Energy, *Annual Electric Utility Data—EIA 906/920 DataFile*, Dec. 2007, *available at* http://www.eia.doe.gov/cneaf/electricity/page/ eia906_920.html. Thus, the 54-plant-reduction represents 10 percent of the current total.

24. *See* Pacala & Socolow, *supra* note 3, at 969. The importance of accounting for the low probability but high consequence climate change effects that may occur when atmospheric CO_2 concentrations exceed target levels such as 450–550 parts per million is also a topic of increasing interest in the economics literature. *See, e.g.*, Martin L. Weitzman, *A Review of* The Stern Review on the Economics of Climate Change, 45 J. ECON. LITERATURE 703, 723–24 (2007) (concluding that it is important to "confront[ ] the issue of what to do about catastrophe insurance against the possibility of thick-tailed rare disasters").

25. The Lieberman-Warner Bill emissions cap for 2012 is set at the 2005 emissions level. *See infra* note 222. The total emissions in 2005 were 6,609 million short tons. The Energy Information Administration projects CO_2 emissions to increase by 0.6 percent per year, which would result in a 2012 level of 6,892 million tons, or an increase of 283 million tons. *See Revised Energy Outlook: Hearing Before the S. Comm. on Energy and Natural Res.*, 110th Cong. 7, 12 (2008) (testimony of Guy Caruso, Administrator, Energy Information Administration, U.S. Department of Energy); *see also* NATURAL RES. DEF. COUNCIL, CONTRIBUTION OF THE ENERGY BILL (H.R. 6) TO MEETING THE GLOBAL WARMING POLLUTION REDUCTIONS TARGETS OF S. 2191, at 2–3 (2007).

26. *See* The Energy Independence and Security Act, P.L. 110-140, § 102, 121 Stat. 1491, 1498–1500 (2007); *see also* UNION OF CONCERNED SCIENTISTS, FACT SHEET: EXTENSIVE BENEFITS ATTAINED FROM FUEL ECONOMY AGREEMENT 1 (2007).

27. The estimated cost of abatement measures in the August 2007 framework of the Lieberman-Warner Climate Security Act, which provided for 10 percent reductions from 2005 greenhouse gas emissions levels by 2020, was $18 per ton in 2015. A tighter cap would increase prices to $20 per ton by 2015. Further, costs would increase to $30 to $40 per ton by 2030 and more than $100 per ton by 2050. *See* BRIAN C. MURRAY & MARTIN T. ROSS, THE LIEBERMAN-WARNER AMERICA'S CLIMATE SECURITY ACT: A PRELIMINARY ASSESSMENT OF POTENTIAL ECONOMIC IMPACT 5–6 (2007). A tighter cap of 15 percent reductions by 2020 was announced on October 18, 2007. *Id.* at 3–5. Carbon taxes of $5 to $30 per ton by 2025 and $20 to $80 per ton by 2050 are expected to achieve similar results. *See The Final Cut*, ECONOMIST, June 2–8, 2007, at 30.

the billions of dollars.[28] These measures have an out-of-pocket cost to the government of $1.5 billion dollars, a sum that is less than one percent of the 2008 federal economic stimulus package[29] and roughly $13 per ton of CO_2 emissions reduced, just over half of the projected total social cost of the Lieberman-Warner Bill.[30] In addition to their relatively low out-of-pocket government costs and total social cost, the low-hanging fruit measures could achieve these reductions at negative abatement costs to individuals and households; that is, by carrying them out, people could both cut emissions and save money.[31] Perhaps most important, these low-hanging fruit measures are only the tip of the iceberg. Many other low-hanging fruit measures exist, and other individual and household actions that do not qualify as low-hanging fruit can generate large emissions reductions and cost savings.

We did not identify the seven low-hanging fruit discussed in this Article through a rigorous, systematic process. The limited availability of data on costs, achievable savings, susceptibility of relevant behaviors to change, and other factors make a systematic, complete assessment well beyond the scope of this analysis. Instead, we selected seven candidates for low-hanging fruit status and assessed each according to our low-hanging fruit criteria. We selected these candidates heuristically, not by systematically applying our low-hanging fruit criteria to a larger body of possible actions, and we do not claim that these seven represent the lowest-hanging fruit. We present them not as optimal targets but as examples that allow us to illustrate how one might conduct a low-hanging fruit analysis and to demonstrate the existence of targets that satisfy our low-hanging fruit criteria. Our conclusion that considerable emissions reductions are achievable for a small investment of federal money and at negative net social cost suggests the utility of conducting more comprehensive research to gather relevant data on the economic and behavioral aspects of greenhouse gas emissions and to assess

28. *See* discussion *infra* Parts I.B, II.B.

29. *See* David M. Herszenhorn, *Congress Votes for a Stimulus of $168 Billion*, N.Y. TIMES, Feb. 8, 2008, at A1.

30. Our conclusions about low-cost opportunities are consistent with those of a recent McKinsey report. *See* JON CREYTS ET AL., MCKINSEY & CO., REDUCING U.S. GREENHOUSE GAS EMISSIONS: HOW MUCH AT WHAT COST?, at x–xii (2007).

31. *See* discussion *infra* Parts I.B, II.B. Precise cost-benefit analyses of these types of behavior changes are rare, but one European study puts the range of negative marginal costs (cost savings) for several of the identified measures at 10 to 90 euros per ton. *See* VATTENFALL, GLOBAL MAPPING OF GREENHOUSE GAS ABATEMENT OPPORTUNITIES (2007), *available at* http://www.vattenfall.com/www/ccc/ccc/577730downl/index.jsp.

systematically a wide range of policy actions to identify a more complete and prioritized set of low-hanging fruit.

We conclude by arguing that although political leadership and increasingly urgent media reports ultimately may shift public opinion in favor of more aggressive regulatory measures, the steps we identify here could yield substantial gains long before that happens. These steps may generate near-term reductions that provide breathing space until the public support for climate measures catches up with the climate science. They may even facilitate the shift in public support in the first place. Reductions in these types of low-hanging fruit emissions also may be necessary to make the remarkably large emissions reductions required to achieve the long-term targets. Direct efforts to reduce individual and household emissions are thus an important addition to the short- and long-term responses to climate change.

I. LOW-HANGING FRUIT CRITERIA

For this analysis, we assume that policymakers seek measures that will achieve the short- and long-term emissions reductions targets with a minimum of political cost. Although a complex mix of factors will influence the attractiveness of any given remedial measure, we examine five factors that are likely to have particular salience for policymakers contemplating measures to reduce greenhouse gas emissions from individuals and households: (1) Magnitude—the aggregate emissions from the targeted activity should be of a size that justifies expending time and money on the measures necessary to reduce the emissions; (2) National Economic Cost—the aggregate U.S. economic cost of the measures necessary to induce the emissions reductions should be equal to or less than that of other measures; (3) Out-of-Pocket Government Cost—the out-of-pocket cost to the government should not exceed levels that are viable in the current or reasonably foreseeable future political climate; (4) Personal Economic Cost—the economic benefits to individuals should equal or exceed the costs; and (5) Other Personal Barriers—individuals should not face other barriers to reducing emissions, such as initial capital investment requirements, lack of necessary infrastructure, substantial time demands, or countervailing personal or social norm-based pressure. Although these factors are interrelated, they are sufficiently distinct to serve as criteria for evaluating potential low-hanging fruit opportunities, and we examine them in more detail below.

A. Magnitude

To constitute low-hanging fruit for policymakers, individual and household actions should include sufficient emissions to justify the investment of time and money to develop and to implement remedial measures. Here we demonstrate that individual behavior in the aggregate accounts for a large portion of the total CO_2 emissions from the United States, and we identify the categories of behavior that contribute the largest share to the individual total.[32] We assess the anticipated emissions reductions from the specific low-hanging fruit actions in Part II.

1. Aggregate Emissions

As stated at the outset, recent scholarship has demonstrated that individual and household emissions make up roughly 30 to 40 percent of U.S. CO_2 emissions. Shui Bin and Hadi Dowlatabadi use an input-output analysis, termed a Consumer Lifestyle Approach, to derive CO_2 emissions that they then attribute to direct and indirect consumer activities.[33] They conclude that direct emissions activities account for 41 percent of total U.S. CO_2 emissions.[34] Michael Vandenbergh and Anne Steinemann, using both top-down and bottom-up analyses, and including only emissions from activities over which individuals have substantial, direct control, calculate household CO_2 emissions at 32 percent.[35] The different estimates arise from small methodological differences, such as whether energy losses at electric utilities are assigned to households.[36]

Even if actual U.S. individual and household aggregate emissions are only at the low end of the range, the emissions are nonetheless remarkably large. For example, if the individual and household share of U.S. emissions was 32 percent in 2000, it equaled almost 2.1 billion tons, or roughly 8

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32. CO_2 contributes to more than 80 percent of the climate-forcing effect of the most important anthropogenic greenhouse gases. *See* Vandenbergh & Steinemann, *supra* note 1, at 1680 n.18 (discussing greenhouse gases).

33. Shui Bin & Hadi Dowlatabadi, *Consumer Lifestyle Approach to U.S. Energy Use and the Related CO_2 Emissions*, 33 ENERGY POL'Y 197, 205 (2005) (estimating the individual and household CO_2 emissions in 1997 at 41 percent of the U.S. total).

34. *Id.*

35. Vandenbergh & Steinemann, *supra* note 1, at 1694 (estimating the individual and household emissions in 2000 at 32 percent of the U.S. total).

36. One methodological difference is that Bin and Dowlatabadi assign energy losses during transmission to individuals and households, but Vandenbergh and Steinemann do not. *Compare* Bin & Dowlatabadi, *supra* note 33, at 201, 203, *with* Vandenbergh & Steinemann, *supra* note 1, at 1741–45.

percent of the world total.[37] This 2.1 billion-ton-total exceeded the total emissions from all industrial sources in the U.S. combined.[38] Aggregate individual and household emissions also exceeded the total emissions from all sources in any country other than China.[39] In short, the individual and household sector in the aggregate generates sufficient emissions to warrant closer scrutiny of the emissions from specific activities and products.

2. Emissions by Activity or Product

Drawing on data from the Energy Information Administration of the U.S. Department of Energy, Figure 1 segments emissions by activity or product.[40] As can be seen, personal automobile usage accounts for a very large percentage of individual emissions—not surprising given that each gallon of gasoline burned results in 19.4 pounds of CO_2 emissions.[41] When we look at household activities, home heating and cooling, collectively, stands out as the largest generator of emissions. Although appliances constitute a relatively low percentage of the household total, their growth (both in size and quantity) is of considerable concern.[42]

37. Vandenbergh & Steinemann, *supra* note 1, at 1694.

38. *Id.* The estimate in Vandenbergh and Steinemann is for the year 2000. *Id.* In our analysis, we assume that the individual and household sector accounted for the same aggregate amount of CO_2 emissions in 2005. This estimate is conservative, since U.S. emissions overall increased during this period. *Id.* at 1693 (noting that total individual and household emissions are likely to have increased since the 2000 period); *see also* Energy Info. Admin, World Carbon Dioxide Emissions From the Consumption and Flaring of Fossil Fuels, 1980–2005 (Sept. 18, 2007), http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls [hereinafter World Carbon Dioxide Emissions] (providing CO_2 emissions data for 2005 and prior years).

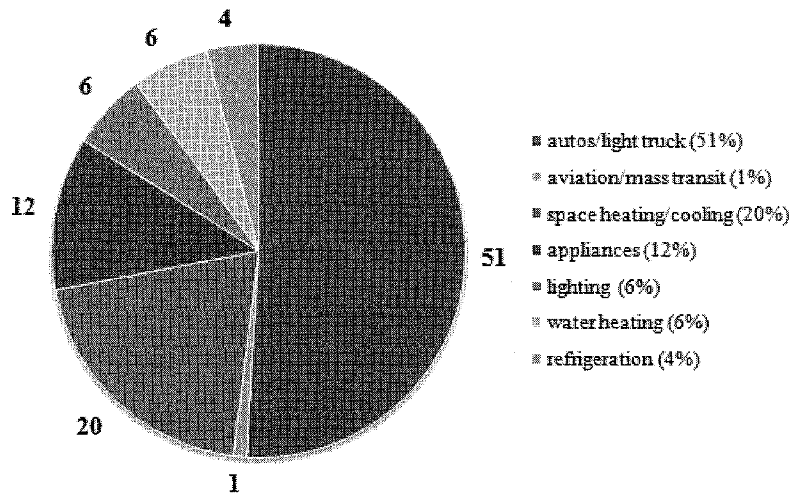
39. Vandenbergh & Steinemann, *supra* note 1, at 1695.

40. *See* U.S. DEP'T OF ENERGY, TRANSP. ENERGY DATA BOOK 4-2 tbl.4.1, 4-3 tbl.4.2 (2007), *available at* http://cta.ornl.gov/data/tedb27/Edition27_Chapter04.pdf [hereinafter DOE, TRANSPORTATION DATA BOOK] (providing personal transportation data); Vandenbergh and Steinemann, *supra* note 1, at 1692–93 (same); U.S. DEP'T OF ENERGY, 2007 BUILDINGS ENERGY DATA BOOK 3-3 tbl. 3.1.3 (2007) [hereinafter DOE, BUILDINGS DATA BOOK], *available at* http://www.doe.gov/energyefficiency/buildings.htm (search for "buildings energy data book") (providing household data).

41. *See* EPA, UNIT CONVERSIONS, *supra* note 23, at 2.

42. *See, e.g.*, Jack N. Barkenbus, *Putting Energy Efficiency in a Sustainability Context: The Cold Facts About Refrigerators*, ENVIRONMENT, Oct. 2006, at 10, 13–16 (concluding that although refrigerators have become more efficient, electricity use by refrigerators "has remained comparable in absolute terms"); *see also* Richard York et al., *Bridging Environmental Science With Environmental Policy: Plasticity of Population, Affluence, and Technology*, 83 SOC. SCI. Q. 18, 20–21 (2002) (noting the importance of malleability or plasticity of behavior).

FIGURE 1: COMPOSITION OF U.S. HOUSEHOLD AND TRANSPORTATION CO_2 EMISSIONS (PERCENTAGES)



The significance of each category of individual and household emissions is apparent when compared to the total emissions from the types of industry categories that are likely to be subject to carbon emissions requirements at the federal, state, or local levels. For example, the 6 percent of household emissions attributed to lighting in Figure 1 constitutes 160 million tons of emissions per year.[43] This figure is roughly equivalent to the combined emissions of all iron and steel producers and paper mills in the United States.[44] The 12 percent attributable to appliances is roughly equivalent to the entire U.S. chemical industry emissions.[45]

B. National Economic Cost

Next, to represent low-hanging fruit, the emissions reductions should be achievable at a lower total national economic cost than competing measures when accounting for both the cost to the government of inducing a desired level of emissions reductions and the cost to the nongovernmental parties of

43. The total pie represents roughly 2.61 billion tons of emissions. *See* World Carbon Dioxide Emissions, *supra* note 38. The percentage break out is as follows: autos/light trucks (1.3 billion tons); aviation/mass transit (26 million tons); space heating/cooling (520 million tons); appliances (310 million tons); lighting (160 million tons); water heating (160 million tons); refrigeration (100 million tons). *See* sources cited *supra* note 40.

44. *See* SCHIPPER, *supra* note 22.

45. *Id.*

making the reductions. For this Article, we use as a benchmark a recent estimate that the marginal cost of the year 2015 requirements of the Lieberman-Warner Bill now pending in Congress will be roughly $20 per ton. By the year 2050, the cost is estimated to increase to over $100 per ton.[46] Not surprisingly, estimates of the magnitude of the carbon tax necessary to achieve the necessary emissions reductions are comparable.[47]

We began our analysis by seeking to identify actions with a national economic cost of about $10 per ton, or roughly half of the projected per-ton cost of the Lieberman-Warner Bill. In short, we began by including in our low-hanging fruit only individual and household actions for which emissions reductions reasonably could be expected to be achieved for a cost of $10 per ton or less. This $10 per ton figure not only is half the cost of the leading federal legislation, but it also compares favorably to the leading economic analyses of the costs and benefits of carbon emissions reductions. The Congressional Budget Office has noted[48] that the estimated benefit per ton of CO_2 reduction (the marginal social cost of carbon emissions) along a trajectory leading to stabilization in the 500 ppm range[49] would be between $8 (the figure proposed by William Nordhaus)[50] and $30 (the figure proposed by Nicholas Stern).[51]

After an initial analysis, however, it became clear that the cost savings arising from reduced energy use are so great for each of the seven low-hanging fruit actions that each of these actions in fact achieves a much more stringent criterion: net social savings, not costs. In short, even if we just account for the cost of energy at current prices and not for other potential cost savings (for example, from the benefits of reduced air pollution from motor vehicles and electric utilities that serve residential customers), the

46. *See* Murray & Ross, *supra* note 27, at 10–12, tbls.A-2 to A-4.

47. Carbon taxes of $5–$30 per metric ton by 2025 and $20–$80 per metric ton by 2050 are expected to achieve similar results to the Lieberman-Warner Bill. *See The Final Cut*, *supra* note 27, at 28 (noting economists estimates of "the carbon price needed to stabilise CO_2 concentrations at 550 parts per million").

48. *See* Peter R. Orszag, Issues in Climate Change: Presentation for the CBO Director's Conference on Climate Change 4–5 (Nov. 16, 2007), *available at* http://www.cbo.gov/ftpdocs/88xx/doc8819/11-16-ClimateChangeConf.pdf.

49. A figure that is in the 500 ppm range is often identified as the target for reducing the risk of catastrophic climate change. *See, e.g.*, O. Hoegh-Guldberg et al., *Coral Reefs Under Rapid Climate Change and Ocean Acidification*, 318 SCIENCE 1737, 1738 (2007).

50. *See* William Nordhaus, The Challenge of Global Warming: Economic Models and Environmental Policy 160 tbl.V-1 (Sept. 11 2007) (unpublished manuscript), *available at* http://nordhaus.econ.yale.edu/dice_mss_091107_public.pdf.

51. *See* NICHOLAS STERN, STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE 304 box 13.3 (2006), *available at* http://www.hm-treasury.gov.uk/media/A/2/Chapter_13_Towards_a_Goal_for_Climate-Change_Policy.pdf.

savings far exceed the costs. In fact, each of the seven actions achieves well over $100 million in net social savings.

Although we make assumptions about the national economic cost only for the low-hanging fruit actions discussed in Part II, we also note here that a number of recent studies suggest that the costs of a wide range of additional individual and household emissions reductions may be surprisingly low. For example, a recent McKinsey report suggests that 11 percent of U.S. greenhouse gas emissions can be eliminated through steps that would have negative marginal costs to the parties that take them, and many of these emissions reductions arise from measures directed at individual and household emissions.[52] A second McKinsey report focusing on global rather than U.S. emissions reductions reaches similar conclusions.[53] Although neither report calculates the total social costs and benefits of the government measures necessary to achieve these reductions, the types of remedies discussed in the reports and the net savings to the affected individuals both suggest that the benefits will exceed the costs by a wide margin.

C. Out-of-Pocket Government Cost

To represent low-hanging fruit, the emissions reductions not only should be achievable at lower total national economic cost than competing measures, but to reduce political resistance the total out-of-pocket cost to the government entities that will stimulate the emissions reductions should also be low. We again use as a rough benchmark for identifying current low-hanging fruit $10 per ton, or half of the projected per-ton marginal cost of the Lieberman-Warner Bill in the year 2015.[54]

We estimate that the recommended seven low-hanging fruit actions can generate roughly 150 million tons in annual emissions reductions by 2014 with $2 billion in out-of-pocket cost to the government for public information campaigns, subsidies, and other activities. As we note above, this $2 billion is less than two percent of the 2008 economic stimulus

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52. *See* CREYTS ET AL., *supra* note 30, at xii, xiii exhibit B (identifying as having "negative marginal costs" energy-efficient technologies related to lighting for residential electronics, residential buildings, fuel economy packages for cars and light trucks, new shell improvements for residential buildings, and residential water heaters).

53. *See* BRESSAND ET AL., *supra* note 19, at 12, 51 (concluding both that the rates of return on energy-conserving measures of 10 percent or more could reduce emissions globally by half of the amount necessary to achieve long-term stabilization of atmospheric CO_2 levels and that "the most substantial productivity improvement opportunity is in the residential sector").

54. *See* MURRAY & ROSS, *supra* note 27, at 10–12, tbls.A-2 to A-4.

package.[55] The seven low-hanging fruit actions thus appear to be achievable at an out-of-pocket government cost of roughly $13 per ton, or just over our $10 per ton target.

D. Personal Economic Cost

To increase efficacy and political viability, low-hanging fruit measures also should achieve emissions reductions at no or even negative abatement costs to individuals and households; that is, by carrying them out, people should be able both to cut emissions and save money. Although many examples exist of costly individual behavior change, studies of consumer and nonconsumer environmentally significant behavior suggest that on balance individuals will act in their pecuniary interest.[56] Individual responses in times of crisis suggest that if the perception that catastrophic climate change is likely becomes widespread, then personal cost constraints may become less important to behavior change efforts. Examples include the summer 2001 California energy crisis,[57] the public response to ozone depleting chemicals in aerosol cans in the 1970s,[58] and the success of scrap drives during World War II.[59] For now, we assume that personal cost matters and that negative marginal cost is a criterion for an action to constitute low-hanging fruit.

E. Other Personal Barriers

The fact that individual and household emissions are very large and that national and personal economic costs are low or negative does not translate automatically into the potential for large-scale savings. Despite considerable success in the development of more efficient technologies, U.S. citizens have been slow to embrace behavioral changes, either through

55. *See* Herszenhorn, *supra* note 29.

56. *See* Stern, *supra* note 11, at 461–63.

57. *See* Emily S. Bartholomew et al., *Conservation in California During the Summer of 2001* (Lawrence Berkeley Nat'l Lab., Paper No. LBNL-51477, 2002), *available at* http://repositories.cdlib.org/lbnl/LBNL-51477; Loren Lutzenhiser et al., *Conservation Behavior by Residential Consumers During and After the 2000–2001 California Energy Crisis*, *in* CAL. ENERGY COMM'N, PUBLIC INTEREST STRATEGIES REPORT 146, 166 (2003), *available at* http://www.energy.ca.gov/reports/100-03-012F.PDF.

58. *See, e.g.*, Peter M. Morrisette, *The Evolution of Policy Responses to Stratospheric Ozone Depletion*, 29 NAT. RESOURCES J. 793, 795 fig.1 (1989) (concluding that aerosol can sales dropped by half even before the adoption of legal requirements regarding ozone depleting chemicals).

59. *See, e.g.*, RICHARD LINGEMAN, DON'T YOU KNOW THERE'S A WAR ON?: THE AMERICAN HOME FRONT 1941–1945, at 15 (2d ed. 2003) (noting that an aluminum scrap drive generated "great piles" of household metal goods at collection points); DAVID HINSHAW, THE HOME FRONT 41 (1943) (stating that the government set a target of recovering one-fourth of all kitchen grease).

adoption of new technologies or direct changes in energy use that could substantially reduce CO_2 emissions. Research on recycling and other environmentally significant behaviors suggests that behavior change is difficult when sustained and substantial changes are necessary.[60] Social scientists cite multiple barriers to behavior changes that reduce energy use, including a high-consumption lifestyle, habits, inattention to energy practices, limited trust in energy providers and government, high discount rates that discourage incurrence of high upfront costs for higher-efficiency technologies, and a principal-agent phenomenon whereby energy decisions are made by others on behalf of the ultimate consumer.[61] Although each of these barriers can be overcome, to constitute a low-hanging fruit action these types of personal barriers must be minimal.

II. THE LOW-HANGING FRUIT

A surprisingly large number of actions may meet the criteria identified in Part I. Although in isolation any one action may appear trivial, when multiplied across part or all of the roughly 110 million households in America,[62] each can produce enormous emissions savings. These actions are the low-hanging fruit of individual and household emissions. They demand relatively little of individuals but produce prompt, significant CO_2 emissions reductions when carried out in large numbers. They have the prospect not only of reducing emissions but also of kick starting the process of engaging the public in its role of reducing emissions, thus enhancing the prospects for other measures as well.

To demonstrate the potential for prompt, large emissions reductions, in this Part we identify seven low-hanging fruit actions and then demonstrate how emissions reductions from these actions can be combined to achieve a

60. *See, e.g.*, Ann E. Carlson, *Recycling Norms*, 89 CAL. L. REV. 1231, 1297–99 (2001) (noting the difficulty of changing some large-number, small-payoff collective action problems).

61. *See, e.g.*, Henry Ruderman et al., *The Behavior of the Market for Energy Efficiency in Residential Appliances Including Heating and Cooling Equipment*, 7 ENERGY J. 101, 115 (1987) (noting high implicit discount rates); NRC, BEHAVIORAL ISSUES, *supra* note 11, at 18–20 (discussing the influence of information on individual energy use); NAT'L RESEARCH COUNCIL, IMPROVING ENERGY DEMAND ANALYSIS 27–42 (Paul C. Stern ed., 1984) (discussing the influence of price changes on individual energy-consuming behaviors).

62. According to the 2000 U.S. Census Bureau, there were 281,421,906 persons in the United States and an average household size of 2.59 persons per household. U.S. Census Bureau, American Factfinder Occupied Housing Characteristics, http://factfinder.census.gov/ (follow "housing" hyperlink; then select "2000" tab; then follow "Occupied Housing Characteristics, for "all states" hyperlink). Dividing the total population by persons per household generates a rough estimate of 108.7 million households, but the actual number is 105,480,101. *Id.*

quantifiable reduction target. In particular, we believe it is possible to reach a target of reducing annual individual and household emissions by 7 percent within five years (in other words, a "7-in-5" target).[63] This amounts to reducing annual CO_2 emissions by roughly 150 million tons below current levels by 2014, if we start in 2009.[64] As discussed in the Introduction, the 2014 savings are the equivalent of removing 26 million automobiles from the road or eliminating the need for 54 large power plants.[65] In terms of the Pacala and Socolow stabilization wedge concept, a single wedge represents annual CO_2 emissions reductions of 370 million tons after five years, so the measures discussed here would produce emissions reductions from the United States alone equivalent to 40 percent of a global wedge after five years.[66]

A. Identifying and Evaluating Interventions for Low-Hanging Fruit

1. Identifying Potential Individual and Household Actions

Table 1 presents a number of examples of actions that may reduce individual and household emissions.[67] Each can be seen as an action that falls in one of four categories: (1) reductions in the number of units (technologies) that Americans use in daily life; (2) reductions in the use of these units; (3) reductions in the amount of fuel consumed in the operation of these units; and (4) reductions in the carbon content of the energy required for the operation of these units. As can be seen from Table 1, most possible actions involve either reduced use (conservation) or increased energy production per unit of CO_2 generated (efficiency).

63. The "7" refers to a 7 percent reduction from 2005 total annual CO_2 emissions from the individual and household sector. The "5" refers to the goal of achieving the total annual reduction in calendar year 2014, five years from 2009.

64. Total U.S. CO_2 emissions were 6.57 billion short tons in 2005. *See* World Carbon Dioxide Emissions, *supra* note 38. If we assume that the individual and household sector accounted for 32 percent of the total, *see supra* notes 34–36 and accompanying text, then its emissions were 2.1 billion tons. A 7 percent reduction in the 2.1 billion ton total would generate reductions of 150 million tons.

65. Calculations derived from EPA, UNIT CONVERSIONS, *supra* note 23.

66. *See* Pacala & Sokolow, *supra* note 3, at 968. A wedge ramps up CO_2 reductions linearly from zero in the first year to 3.7 gigatons after fifty years, so at five years a wedge would comprise 370 million tons of CO_2, and our 150 million ton reduction is 40 percent of 370 million tons. *See id.*

67. This list of practical actions was developed over the course of several meetings in June to November 2007 by participants in the Climate Change Research Network.

TABLE 1: POTENTIAL INDIVIDUAL AND HOUSEHOLD ACTIONS[68]

A. Reduce Number of Units (autos, appliances, heating/cooling units, lights)	1. Participate in car-sharing plans in urban areas 2. Participate in auto and appliance retirement programs
B. Reduce Use of Units	3. Take public transportation 4. Carpool 5. Move closer to work 6. Bike/walk 7. Telecommute 8. Take fewer airline flights 9. Turn off individual appliances when not in use 10. *Reduce "phantom" electricity use or "leakage"* 11. Use natural drying methods when possible (clotheslines) 12. Install power save monitors 13. Turn lights off when not in use 14. Purchase motion sensing units for on-off features 15. Install fans 16. *Adjust household thermostat settings* 17. Close unneeded rooms 18. Use wood fireplace rather than gas 19. Install programmable thermostats
C. Reduce Amount of Fuel Consumed	20. Purchase more fuel efficient vehicle 21. Use overdrive/cruise control 22. Use slower acceleration 23. Reduce unnecessary braking 24. Travel slower on highway 25. *Inflate tires* 26. *Reduce idling* 27. Reduce air conditioning in vehicle 28. *Change air filter in vehicle*

68. Measures in italics are discussed in detail in this Article.

C. Reduce Amount of Fuel Consumed (continued)	29. Remove excess weight in vehicle 30. Get tune-up/check oxygen sensor 31. Purchase smaller/more fuel efficient appliances 32. *Adjust temperatures (for water heater)* 33. Wash clothes in warm water and rinse in cold 34. Install low-flow showerheads 35. Place blanket on water heater 36. *Substitute CFLs or LEDs for incandescent lights* 37. Change air filters in household 38. Replace heat pump filters 39. Tune up furnace and heat pump on regular basis 40. Purchase high efficiency furnaces and heat pumps 41. Add caulking, weather-stripping around windows, doors, and other spaces 42. Add insulation 43. Take shorter airline trips 44. Fly during the day 45. Increase recycling volume and rate
D. Reduce Carbon Content of Fuel	46. Use alternative fuels in vehicles • ethanol • biodiesel • electricity • hydrogen 47. Install photovoltaic units for electricity generation 48. Install solar thermal units for water heating 49. Buy "green power" from electricity supplier

We have identified seven of these actions that in the aggregate can provide a reasonable chance of achieving the 7-in-5 target. Additional actions that also fit the low-hanging fruit characterization could enable the target to be surpassed, but we focus on only seven here. At this stage, it is more important to demonstrate the opportunities available from a limited number of initiatives than to provide a laundry list of possibilities. The seven actions are as follows:

- Reduce the component of motor vehicle idling that has net costs to the driver;
- Reduce standby power electricity use;
- Accelerate the substitution of compact fluorescent light bulbs (CFLs) for incandescent bulbs;
- Adjust temperature settings two degrees in both summer and winter;
- Decrease household thermostat settings on water heaters;
- Maintain the recommended tire pressure in personal motor vehicles; and
- Change air filters in personal motor vehicles at recommended intervals.

An alternative approach to identifying a specific list of actions for emissions reductions is simply to promote the 7-in-5 target and to let each household determine its own path to meeting the target. This approach is analogous to how most individuals approach personal dieting. In fact, the concept of a low-carbon diet has been promoted as a means for individuals to contribute to reducing climate change risks.[69] The diet target in this case would be 7 percent of a household's carbon "weight," and each residence would be free to choose the actions that collectively would meet the target.

Although this approach is appealing, it also has major shortcomings. Most individuals will not want to measure or to account for specific carbon emissions associated with a menu of activities. Unfortunately, no comprehensive tools exist for quick and easy emissions reductions calculations. Existing sources of information are diffuse, inconsistent, and unlikely to provide sufficiently timely feedback to the individual.[70] Consequently, attentive individuals are likely to choose certain actions a la carte, hoping or simply assuming they will meet the target. This indeterminacy is likely to

69. *See* DAVID GERSHON, LOW CARBON DIET: A 30-DAY PROGRAM TO LOSE 5,000 POUNDS 5 (2006); *see also* The Atkinson Diet—A Local Response to Global Warming, http://www.theatkinsondiet.com (last visited June 15, 2008).

70. *See* J. Paul Padgett et al., *A Comparison of Carbon Calculators*, 28 ENVTL. IMPACT ASSESSMENT REV. 106 (2008).

lead to recidivism—just as it does to most weight loss efforts.[71] Fortunately, the prescriptive list of measures advocated in this Article avoids such fatal indeterminacy.

2. Evaluating Emissions Reductions and Estimating Cost

Although below we quantify the contribution each of the seven actions could make toward the 7-in-5 target, we note that quantification of the emissions reductions achievable from these types of actions is an imprecise art. In each case, doing so requires an estimate not only of current emissions, but also of the number of households likely to embrace the chosen action. We do not assume full public adoption, and as a result our estimate is not a rendering of a measure's full emissions reduction potential. Our goal is not to provide precise, data-driven estimates of likely levels of behavior change, but rather to increase the awareness among policymakers and academicians of the potential role of the individual and household sector by demonstrating that on reasonable assumptions, prompt and large emissions reductions can be made at surprisingly low cost.

As stated in Part I, we began with a $10 per ton benchmark in evaluating the potential remedial measures. In other words, we examined whether the target level of emissions reductions (7 percent of year 2005 total individual and household CO_2 emissions, or roughly 150 million tons) could be achieved at a total national economic cost of roughly $10 per ton (for each ton of CO_2 reduced in 2014).[72] We were able to identify seven actions that not only meet this target, but also achieve net social savings of several billion dollars. In fact, the actions discussed below also can achieve reductions that meet the more stringent criterion of total out-of-pocket government cost in the $10 per ton range (all are less than $13 per ton). Although a wide range of policy options are available to achieve these reductions, we examine two general approaches: a comprehensive general public information campaign targeting all seven behaviors and a mix of a comprehensive general public information campaign, along with action-specific

71. *See, e.g.*, L. Bacon et al., *Evaluating a "Non-Diet" Wellness Intervention for Improvement of Metabolic Fitness, Psychological Well-Being and Eating and Activity Behaviors*, 26 INTL. J. OBESITY 854 (2002) (evaluating a weight-loss program).

72. The 7-in-5 emissions reduction target and our cost calculations are intended to be rough approximations. We do not account for emissions reductions that may occur before or after the 2014 target year in which we estimate that reductions of 150 million tons could occur. We also assume that although much of the $1.5 billion will be spent in 2014, some earlier expenditures will occur. We do not apply a discount rate to costs expended in future years.

subsidies (for example, provision of free household energy meters to facilitate adjustments in temperature settings) and other interventions.

a. General Public Information Campaign

If the target emissions reduction level is 150 million tons and the target cost is $10 per ton, expenditures can be in the neighborhood of $1.5 billion, so long as the targeted actions themselves are not costly to the individual. In fact, each of the low-hanging fruit discussed below meet the personal economic cost criterion by generating net savings to the individual or household. As a result, far more than $1.5 billion could be expended if the target is net social costs (national economic costs) of $10 per ton. To be conservative, however, we use the $1.5 billion figure.

The simplest approach would be to expend $1.5 billion on a public information campaign. Although it is not possible to know the extent to which a campaign on this unprecedented scale would change individual carbon-emitting behavior, empirical studies provide some basis for optimism. Public information campaigns directed at environmentally significant behaviors have had mixed success in the past, but many of them were severely underfunded.[73] Recent literature reviews have concluded that more than half of the well-designed and funded programs have resulted in significant and positive behavior change, with changes in the targeted behaviors of 7 to 30 percent.[74] It is quite possible that a well-managed public information campaign that had a budget of $1.5 billion and that reflected the most important advances in the social and behavioral sciences would generate reductions in the low-hanging fruit sufficient to achieve the 150 million ton target.[75] In comparison, the national Truth campaign—an anti-smoking effort—spent about $100 million per year for each of three years, and there

73. *See* Vandenbergh, *supra* note 16, at 613 n.373.

74. *See, e.g.*, Monica Campbell et al., *A Systematic Review of the Effectiveness of Environmental Awareness Interventions*, 91 CANADIAN J. PUB. HEALTH 137, 142 (2000) (reviewing Canadian environmental public education campaigns and finding that more than half of the studies reported changes in desired behaviors); Henk Staats et al., *Effecting Durable Change: A Team Approach to Improve Environmental Behavior in the Household*, 36 ENV'T. & BEHAV. 341 (2004) (providing an example of a well-crafted public education campaign that generated a 7 percent reduction in water use and a roughly 30 percent reduction in solid waste generation).

75. Our estimates are optimistic in terms of what public information campaigns frequently deliver. We assume that there will be an effective public-private campaign for adoption (to be discussed later) that will grab the public's attention. Participant numbers will only be known after the program begins and as the result of careful public surveys. In addition, estimates of potential emissions savings in the literature and in the popular press vary greatly, based on differing and sometimes unstated assumptions. Rather than attempt to resolve these differences in the near term, we have provided a range of estimates to capture the extent of possible outcomes.

is some evidence that it was effective.[76] It is far from clear, however, that a general national public information campaign would be the optimal approach, and we evaluate a more targeted program below.

b. Combined General and Action-Specific Interventions

The second approach we examine is a combination of a general public information campaign with targeted subsidies or other interventions for each of the seven low-hanging fruit actions. For our subsequent analysis, we assume an expenditure of roughly $800 million on a general public information campaign concerning all seven low-hanging fruit actions, and $100 million each on interventions targeted at the seven behaviors, for a total of $1.5 billion. We do not claim that an allocation of $100 million to each low-hanging fruit action is the optimal distribution of funds, but we use these figures to demonstrate the plausibility of the reductions that could be achieved from total government expenditures at around the $10 per ton level. The one exception to this allocation is in our choice to reallocate half a share ($50 million) from automobile idling reduction to accelerating adoption of CFLs. We fear sharply diminishing marginal returns in attempts to change idling behavior by more than roughly 10 percent,[77] but replacing hundreds of millions of incandescent light (IL) bulbs with compact fluorescents is feasible and could yield significant reductions in CO_2 emissions.[78]

B. Seven Low-Hanging Fruit Actions

This analysis examines the extent to which the seven low-hanging fruit actions meet the five criteria identified in Part I.

1. Reduce Personal Motor Vehicle Engine Idling

Approximately 5 to 8 percent of gasoline consumed by personal passenger vehicles is consumed while idling.[79] A typical personal vehicle releases 570

76. *See, e.g.*, Matthew C. Farrelly et. al, *Evidence of a Dose-Response Relationship Between "Truth" Antismoking Ads and Youth Smoking Prevalence*, 95 AM. J. PUB. HEALTH 425, 425, 428–30 (Mar. 2005); Lisa K. Goldman & Stanton A. Glantz, *Evaluation of Antismoking Advertising Campaigns*, 279 J. AM. MED. ASS'N 772 (1998).

77. *See* discussion, *infra* Part II.B.1.

78. *See* discussion, *infra* Part II.B.3.

79. *See* Yoshitaka Motoda & Masaaki Taniguchi, *A Study on Saving Fuel by Idling Stops While Driving Vehicles*, 4 PROC. E. ASIA SOC'Y FOR TRANSP. STUD. 1335, 1344 (2003); K. Ueda et al., *Idling Stop System Coupled With Quick Start Features of Gasoline Direct Injection* 1 (SAE Technical

to 920 pounds of CO_2 per year and the total emissions due to personal vehicles in the United States are 55 to 90 million short tons per year.[80] If a vehicle will idle for more than 5 to 10 seconds, shutting the engine off and restarting it when the driver is ready to resume driving typically will not only reduce fuel consumption, but also will reduce wear-and-tear on the engine, improve fuel economy, and improve the performance of catalytic converters.[81] For idle times of 45 seconds or more, the savings in fuel consumption and engine maintenance from shutting off the engine vastly exceed the minor wear-and-tear associated with restarting the engine.[82] Ultimately, a combination of new technology and behavior changes may make it possible to reduce idling by at least 50 percent,[83] but for this Article, we choose a much more conservative target of a 10 percent reduction because we are focusing on behavior changes that can be easily achieved at low cost. This would reduce CO_2 emissions by 6 to 9 million tons per year

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Paper 2001-01-0545, 2001); Gordon W.R. Taylor, Review of the Incidence, Energy Use and Costs of Passenger Vehicle Idling 4-1 (Aug. 2002) (unpublished report, on file with the UCLA Law Review).

80. The average household vehicle consumes 592 gallons of fuel per year for personal use. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, PUBL'N NO. 0464, HOUSEHOLD VEHICLES ENERGY USE: LATEST DATA AND TRENDS 60 tbl. A3 (2005) [hereinafter EIA, HOUSEHOLD VEHICLES]. Each gallon of fuel consumed produces 19.4 pounds of CO_2. ENVT'L. PROT. AGENCY, EPA420-F-05-001, EMISSION FACTS: AVERAGE CARBON DIOXIDE EMISSIONS RESULTING FROM GASOLINE AND DIESEL FUEL 2 (2005), http://www.epa.gov/otaq/climate/420f05001.pdf. Thus, the average personal vehicle produces 11,485 pounds, or 5.7 short tons, of CO_2 per year. Five to eight percent of this is 574 to 918 pounds, which may be rounded to 570 to 920 pounds. Total fuel consumption for personal use in the United States is 113 billion gallons per year. EIA, HOUSEHOLD VEHICLES, *supra*, at 53. This produces 2.19 trillion pounds, or 1.10 billion short tons of CO_2. Five to eight percent of this total is 55 to 88 million tons, which may be rounded to 55 to 90 million tons.

81. *See* Taylor, *supra* note 79, at 4-1, 4-2; Ueda et al., *supra* note 79, at 9–10 figs.14–15; M. Matsuura et al., *Fuel Consumption Improvement of Vehicles by Idling Stop* 3 (SAE Technical Paper 2004-01-1896, 2004); U.S. ENVTL. PROT. AGENCY, 420-F-93-002, YOUR CAR AND CLEAN AIR: WHAT YOU CAN DO TO REDUCE POLLUTION 3 (1994), http://www.epa.gov/otaq/consumer/18-youdo.pdf.

82. *See* Taylor, *supra* note 79, at 4-2.

83. No reliable data exist on what fraction of idling in the United States satisfies either the 10-second or the 45-second criteria. More thorough studies conducted in Japan find that at least 50 percent of idling meets these criteria. Hideaki Takahara et al., *Continuously Variable Transmission Control System for Toyota Intelligent Idling Stop System* 8–9 (SAE Technical Paper #2004-01-1635, 2004) (noting that idling corresponds to 17.9 percent of fuel consumption in Japan and that an idle-stop can reduce fuel consumption by 9 percent, which is 51 percent of total consumption while idling). A much larger fraction of U.S. driving is on highways or rural roads than Japan, so the overall fraction of fuel consumed while idling should be smaller in the United States. But since most idling will occur in city driving, we believe that it is reasonable to assume that a similar fraction of U.S. idling is likely to be longer than 10 seconds and thus reasonable for drivers to reduce. For this Article, however, we make the much more conservative assumption that our policy measures will reduce idling by 10 percent, so the viability of this policy prescription relies only on the assumption that at least 10 percent of U.S. idling, as opposed to measured values of 51 percent of Japanese idling, satisfies the 10-second criterion. The lack of detailed data on U.S. idling makes it clear that more detailed research on idling in the United States would be valuable.

while reducing criteria pollutants and saving the average driver somewhere in the range of $9 to $14 per year.[84]

One significant obstacle to changing behavior regarding idling vehicles is the common set of false beliefs that cars need to warm up for a significant time before being driven. Another is that shutting off the engine briefly and then restarting it consumes more fuel and produces more pollution than allowing the engine to idle.[85] Although this may once have been the case, modern fuel-injected engines need almost no warm-up-time, and restarting a warm engine consumes less fuel and emits less pollution than idling for 5 to 10 seconds.[86] Countering this misinformation with a public education campaign may affect idling behavior by aligning drivers' economic self-interest with emissions reduction. Anti-idling laws also may have value in signaling normative expectations that drivers not idle their engines for extended periods while waiting to drop off and pick up passengers, or in drive-through lines at banks, fast-food restaurants, and similar facilities.[87]

A number of experiments performed in Canada under the auspices of Natural Resources Canada have found that idling can be reduced by public information campaigns. For example, the city of Mississauga performed a public education campaign to reduce idling.[88] Although it was not possible to monitor idling for the entire city, one part of this campaign carefully measured idling behavior in 500 cars belonging to parents as they picked up and dropped off children at school.[89] This campaign reduced the number of cars idling from 54 to 29 percent of the sample and reduced the mean duration of idling from 8 to 3.5 minutes, a 76 percent reduction in total idling.[90] The campaign cost Can $80,000 (US $51,000 in 2002) for one year

84. Reducing 55 to 90 million tons of CO_2 emission due to idling by 10 percent would save 5.5 to 9 million tons, which we round to 6 to 9 million tons. Saving 0.5 to 0.8 percent of 592 gallons of fuel at $3 per gallon generates a total of $8.80 to $14.20, which we round to between $9 to $14. *See* EIA, HOUSEHOLD VEHICLES, *supra* note 80, at 60 tbl.A3 (providing emissions due to idling and average household vehicle fuel consumption).

85. For a discussion of idling beliefs, *see* Vandenbergh & Steinemann, *supra* note 1, at 1701.

86. *See* Taylor, *supra* note 79, at 4-1; Ueda et al., *supra* note 79, at 9 fig.14; Matsuura, *supra* note 81, at 4.

87. *See, e.g.*, Richard H. McAdams, *The Origin, Development, and Regulation of Norms*, 96 MICH. L. REV. 338, 400 (1997) (noting that the enactment of legal requirements can convey information about the regulated conduct in addition to creating a risk of a formal legal sanction for noncompliance).

88. LURA CONSULTING, TOWARDS AN IDLE-FREE ZONE IN THE CITY OF MISSISSAUGA: FINAL REPORT 1-5 (2003).

89. *Id.* at 13.

90. *Id.*

for a city of 625,000, or US $0.08, per resident.[91] If these numbers are representative of broader changes in idling behavior, the emissions reductions would total around 80,000 tons of CO_2 per year for the city, and the cost of achieving those reductions via a public education campaign to change behavior would be US $0.64 per ton of CO_2.[92] School drop-off and pick-up activities are not typical, however, and therefore the foregoing numbers probably significantly overestimate the impact of the campaign.[93] Nonetheless, even if the actual idling reductions are 20 times lower, the cost would still total only slightly more than US $10 per ton.

Additionally, the city of Edmonton, Alberta, has had great success changing the on-the-job driving behavior of city employees to improve their fuel economy. An education and training program called Fuel Sense has been in place since 2000 at an annual cost of Can $45,000 (US $29,000 in 2002).[94] By reducing idling and encouraging more efficient driving, the program has reduced annual fuel consumption of city vehicles by 10 percent, saving over Can $175,000 (US $110,000) annually and reducing CO_2 emissions by 340 tons per year.[95] Each year more drivers are educated and both greenhouse gas emissions and fuel costs are reduced. Although US $29,000 may appear to be a large amount to spend to reduce emissions by only 340 tons ($85 per ton if the fuel savings are excluded), the fact that the fuel savings recoup the education costs more than threefold in a single year suggests that spending public funds for educational programs such as this would be justified by taxpayers' fuel savings and by the goal of better insulating against oil supply

91. *Id.* at 25. For exchange rates, *see* Financial Mkts. Dep't Bank of Canada, Annual Average of Exchange Rates (2002), http://www.bank-banque-canada.ca/pdf/nraa02.pdf (indicating that the average exchange rate in 2002 was Can $1.570 to US $1.00).

92. A typical personal vehicle emits 574 to 918 pounds of CO_2 per year while unnecessarily idling. *See supra* note 80. To simplify the following discussion we take the average of this range, 746 pounds. Reducing this by 76 percent would cut annual CO_2 emissions by 567 pounds, or 0.28 tons per vehicle. Canada has 0.44 automobiles per capita. FED. HIGHWAY ADMIN., FHWA-PL-01-0102, OUR NATION'S HIGHWAYS 2000, at 8 (2000). See also underlying data, accessed at Office of Highway Policy Info., U.S. Dep't of Transp., Annual Automobile Vehicle Miles of Travel (VMT) per Capita and Number of Automobiles per Capita 1997, http://www.fhwa.dot.gov/ohim/onh00/bar4.htm (last visited July 14, 2008). Consequently, we estimate CO_2 reductions of around 80,000 tons total in a city of 625,000 residents. US $51,000 divided by 80,000 tons CO_2 equals US $0.64 per ton CO_2.

93. The school intervention targeted extended idling, but a number of studies suggest that more than half of automobile idling occurs at traffic signals or in stop-and-go traffic, and lasts less than one minute. Changing behavior at a stop light is probably much more difficult than changing behavior in a driveway and could raise other safety and efficiency issues. *See* Taylor, *supra* note 79, at 2-1 to 2-6.

94. TRANSP. CANADA, CASE STUDY NO. 24, TP14269E, FUEL SENSE: MAKING FLEET AND TRANSIT OPERATIONS MORE EFFICIENT 1, 3 (2004). For the exchange rate, see Bank of Canada, *supra* note 91.

95. TRANSP. CANADA, *supra* note 94, at 3.

shocks. Additionally, the drivers' newly acquired habits persist after they are trained, and each year the program trains new drivers, so the fuel savings and emissions reductions continue to grow.[96] Over time, the program expects to more than double the fuel savings and emissions reductions without increasing its operating budget.[97]

Other research by Natural Resources Canada suggests that as successful as simple education campaigns can be, these campaigns may function better in conjunction with laws that exact penalties for excessive idling.[98] In ten cities and communities around Canada, public education programs that addressed myths about idling and explained the need to reduce idling were combined with legal idling bans to reinforce the sense that idling is a serious problem. Evaluations found that the combination of education and legal measures succeeded in reinforcing driver awareness, but quantitative studies of idling reduction were not performed.[99]

Another obstacle to changing idling behavior is the value of the driver's attention. Although this is not a monetary cost, it clearly costs the driver to pay attention to turning off the engine when the vehicle is stationary. Hybrid cars automatically shut off their engines when idling, and as much as 30 percent of the difference in fuel economy between hybrid and conventional cars is due to this automatic idle-stop feature.[100] Similar devices, called integrated starter-generators (ISGs) or micro-hybrid powertrains, exist for conventional gasoline engines. Some manufacturers are now offering them as optional equipment in Europe, and they will soon be offered in the United States.[101] The U.S. Environmental Protection Agency (EPA) estimates that with economies of scale ISGs would cost around $300 to $650 packaged with related energy-saving technology and

96. *Id.* at 3 (noting that retesting drivers a year after training found excellent retention of efficient driving skills).

97. *Id.* (concluding that "[a]s more drivers are trained in Fuel Sense principles, it is estimated that annual fuel cost savings could well be over half a million dollars").

98. *See* NATURAL RES. CAN., THE CARROT, THE STICK, AND THE COMBO: A RECIPE FOR REDUCING VEHICLE IDLING IN CANADIAN COMMUNITIES 6–7 (2005).

99. *Id.* at 21–22.

100. *See, e.g.*, HIDEAKI TAKAHARA ET AL., Continuously Variable Transmission Control System for Toyota Intelligent Idling System, SAE TECHNICAL PAPER #2004-01-1635, at 6–7 (Fig. 11-12) (2004) (analyzing the Toyota hybrid engine).

101. *See* Don Sherman, *Features Out of Sight, But Top of Mind*, N.Y. TIMES, Dec. 30, 2007, Technology Section, at 2 (noting that Mazda in the 2009 model year will offer an ISG automatic idle-stop option in the United States); *What's New: Technology*, AUTOMOTIVE NEWS, Dec. 3, 2007, at 16F; Vito J. Racanelli, *Luxury Autos 2007: Green Machine*, BARRON'S, Sept. 24, 2007, at 33.

would reduce fuel consumption by 5 to 9 percent, allowing fuel savings to repay the added purchase price in around two to seven years.[102]

Consumers apply very different mental accounting to large infrequent expenses, such as appliance or automobile purchases, than to smaller recurring expenses, such as gasoline or electricity. This difference leads consumers to reject paying extra for energy efficient cars or appliances, even when the reduced fuel or electricity bills would repay the added purchase price at a favorable rate of return.[103] This effect creates an inefficient market for anti-idling and other fuel efficiency measures for automobiles, even disregarding pollution externalities.[104] Since measures to reduce pollution externalities also would work in the consumer's favor, it may be desirable to correct for the anomalous consumer behavior with either rebates or technology mandates. Since many automobile manufacturers are already adding automatic anti-idle options to their production lines, mandating such equipment would not impose a great hardship. In addition, if we consider the owner's savings in fuel and maintenance, the total net cost of mandating this technology would be negative. However, mandating technology, such as ISGs, requires a long lead time because factories lock in designs many years in advance. In any case, until anti-idle technology thoroughly penetrates the motor vehicle market, measures to address idling behavior will remain important. Thus, a short-term program focusing on five-year deliverables will need to balance public education, consumer incentives for purchasing idle-stop options currently offered by auto manufacturers, and possibly laws focusing on individual behavior, such as the Canadian anti-idling laws.

An idling-reduction program similar to Mississauga's, if applied to the entire United States, would cost around $25 million.[105] If such a campaign, together with an additional $25 million in aid to states for adopting and

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102. *See* JEFF ALSON ET AL., ENVTL. PROT. AGENCY, EPA420-R-05-012, INTERIM REPORT: NEW POWERTRAIN TECHNOLOGIES AND THEIR PROJECTED COSTS 17 tbl.2-1 (2005). The average vehicle uses 592 gallons of gasoline per year, at a cost of $1,776 for $3.00 per gallon gasoline. EIA, HOUSEHOLD VEHICLES, *supra* note 80, at 56. Reducing this by 5 to 9 percent would save $89 to $160 per year. Dividing the $300 to $650 cost of an ISG by this savings yields a two to seven year payback time.

103. *See* George Loewenstein and Drake Prelec, *Anomalies in Intertemporal Choice: Evidence and an Interpretation*, in CHOICE OVER TIME 119, 137–38 (George Loewenstein & Jon Elster eds., 1992).

104. We use the term automobiles to include light trucks, such as SUVs, that are used for personal driving.

105. This is $0.08 per person for 300 million people in the United States. *See supra* note 62. The U.S. automobile ownership rate is 0.48 per capita, which is only slightly higher than Canada's 0.44 per capita, so we expect the cost per driver to be similar or even slightly less in the United States than in Canada. FED. HIGHWAY ADMIN., *supra* note 92, at 8.

enforcing anti-idling laws,[106] reduces idling by even 10 percent, annual CO_2 emissions would drop by 6 to 9 million tons[107] at a cost of $6 to $9 per ton. Additional environmental benefits would accrue from reduced emissions of air pollutants that produce smog and cause respiratory illness. Beyond the environmental benefits, a 10 percent reduction in idling would save car owners $1.7 to $2.7 billion per year in fuel costs.[108]

Alternatively, a $50 million federal program to rebate $150 per ISG would fund ISGs for 270,000 cars, allowing 20 percent for administrative overhead. In the first full year of the new vehicles' use, this would save 78,000 to 138,000 tons of CO_2 at a cost of $360 to $640 per ton.[109] When emissions reductions are considered over the vehicles' sixteen-year average lifetime,[110] this would eliminate 1.2 to 2.2 million tons of CO_2 emissions, reducing the cost per ton to $23 to $42. Although this figure might seem to be a steep price to pay for CO_2 reduction, if one also considers the $24 to $43 million per year that would be saved in gasoline by the drivers of cars in this program,[111] the net social benefit would exceed the costs so long as the subsidy program did not merely attract free riders.[112] Such a subsidy may not be the most effective way to stimulate adoption of ISGs, however, and further research is warranted before proposing such a policy. In the

106. $25 million would finance 860 programs similar to Edmonton's. These could be targeted toward large cities, where idling is more prevalent due to greater traffic congestion and where a higher density of automobiles could improve the number of drivers reached by a public education program.

107. Idling is responsible for 55 to 90 million tons of CO_2 per year. *See supra* note 80.

108. Every year 5.7 to 9.0 billion gallons of gasoline are consumed while idling during personal use. *Supra* note 80. Reducing this by 10 percent would reduce consumption by 570 to 900 million gallons of gasoline per year. At $3.00 per gallon, this would save $1.7 to $2.7 billion per year.

109. The average personal vehicle produces 5.7 tons of CO_2 per year. *Supra* note 92. Five to nine percent of this would be 0.29 to 0.51 tons per year per vehicle. Multiplying this figure by 270,000 vehicles yields a total annual emissions reduction of 78,000 to 138,000 tons of CO_2. Dividing $50 million by this emissions reduction yields $360 to $640 per ton.

110. AIR RES. BD., CAL. ENVTL. PROT. AGENCY, FINAL STATEMENT OF REASONS, REGULATIONS TO CONTROL GREENHOUSE GAS EMISSIONS FROM MOTOR VEHICLES 12 (2005), *available at* http://www.arb.ca.gov/regact/grnhsgas/fsor.pdf (noting that the average vehicle lifetime is 16 years); AIR RES. BD., CAL. ENVTL. PROT. AGENCY, ADDITIONAL SUPPORTING DOCUMENT: ESTIMATION OF AVERAGE LIFETIME VEHICLE MILES OF TRAVEL 1 (2004), *available at* http://www.arb.ca.gov/regact/grnhsgas/vmt.pdf (noting that the average lifetime is 16 year for cars and 18 years for light-duty trucks).

111. Multiplying the $89 to $160 annual fuel savings for an average personal vehicle, *supra* note 102, by 270,000 vehicles yields $24 to $43 million per year in fuel savings.

112. *See, e.g.*, Rob Aalbers et al., *Subsidising the Adoption of Energy-Efficient Technologies: An Empirical Analysis of the Free-Rider Effect*, *in* KORNELIS BLOCK ET AL., THE EFFECTIVENESS OF POLICY INSTRUMENTS FOR ENERGY EFFICIENCY IMPROVEMENT IN FIRMS 31, 31–49 (2004); CHRIS ANN SEBOLD ET AL., PAC. GAS & ELEC. STUDY NO. PG&E-SW040, A FRAMEWORK FOR PLANNING AND ASSESSING PUBLICLY FUNDED ENERGY EFFICIENCY 5-23, 6-18 to 6-19 (2001).

short run, policies to promote behavioral idling reduction appear to have more impact per dollar spent.[113]

Although anti-idling education campaigns can be very cost-effective, they are likely to suffer from diminishing marginal returns. Therefore, rather than investing the nominal $100 million in anti-idling measures, we propose a $50 million program of education, law adoption, and enforcement. Many state and local governments have anti-idling laws in place, but they are rarely enforced and typically prohibit only idling times that greatly exceed the recommended times for saving fuel and reducing CO_2 emissions.[114] Small changes in enforcement and idling time limits may be possible with little public resistance. If we assume the out-of-pocket government cost to be $50 million for a program to reduce idling by 10 percent and add one-fourteenth of the cost of the $800 million general public information campaign ($57 million), then the total government cost is $107 million. If the emissions reductions are 6 to 9 million tons per year, the costs to the government per ton of CO_2 reduced are $12 to $19. The aggregate savings to households from reduced gasoline consumption would be $1.7 to $2.7 billion per year, however. As a result, the $107 million cost would be significantly less than the $1.7 to $2.7 billion annual savings on gasoline, and the program would reduce CO_2 emissions by millions of tons at a significantly negative net national economic cost.

2. Reduce Standby Power Use

Most people probably do not know that their appliances continue to draw power when they are not in use. Many products do so in order to turn on quickly when the consumer presses the power button. This means that households are paying for electricity usage 24 hours-a-day, 365 days-a-year, whether they are using appliances or not. And this standby power, sometimes called phantom power, vampire power, or leakage, can occur if many appliances throughout the household are simultaneously drawing power. Large electronics, especially televisions, are notable for consuming particularly large amounts of standby power. The growth of home-computer networks,

113. More effective ways to encourage adoption of ISGs than direct consumer rebates also may exist. We are not aware of the best practices studies of programs to encourage the purchase of energy-efficient vehicles, but there is extensive literature on best practices to encourage purchase of energy-efficient appliances for the home, and many of these lessons may be transferable. *See, e.g.*, sources cited *infra* note 168.

114. *See generally* ENVTL. PROT. AGENCY, EPA PUBL'N NO. A420-B-06-004, COMPILATION OF STATE, COUNTY, AND LOCAL ANTI-IDLING REGULATIONS (2006) (identifying state and local anti-idling laws).

especially wireless networks, is also responsible for a significant fraction of the growth of household electricity consumption.[115]

Despite a worldwide effort to reduce levels of standby power requirements in appliances, including Energy Star and related low-power certification programs for some products,[116] the gains from these programs have been undermined by other consumer electronics trends. Most notably, these trends include the growth in large-screen televisions, which consume far more power than traditional televisions and come with user options configured by default to use maximum power.[117] Some large-screen televisions can use as much power in standby mode as a refrigerator.[118] According to the U.S. Department of Energy, 40 percent of electricity consumption by home electronics occurs in standby mode.[119] Certain appliances, such as microwave ovens and video recorders (VCRs), actually consume more electricity over the course of a year running their clock displays in standby mode than they do while in use.[120]

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115. *See* Alan Meier & Bruce Nordman, Energy Efficient Networks: Practical Problems, Presentation at the Standby Power Consumption Workshop 8 (Sept. 25–26, 2007) (slide presentation available at http://www.conae.gob.mx/work/sites/CONAE/resources/LocalContent/5343/1/AlanMeier2.pdf) (concluding that home and office computers and networking equipment represent 7 percent of all U.S. electricity consumption and that the potential direct savings from reducing standby consumption by networks is one billion dollars per year).

116. Energy Star is a program jointly administered by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy. It establishes energy-efficiency standards and certifies products that comply. The goal of this program is to help consumers reduce their energy consumption, thereby saving money and reducing pollution. According to EPA figures, use of Energy Star certified products saved U.S. consumers in 2007 more than $16 billion in utility bills and reduced CO_2 emissions by more than 48 million short tons. ENVT'L PROT. AGENCY, ENERGY STAR OVERVIEW OF 2007 ACHIEVEMENTS 1 (2008), *available at* http://www.energystar.gov/ia/partners/publications/pubdocs/2007%20CPPD%204pg.pdf; ENVT'L PROT. AGENCY, ENERGY STAR: THE POWER TO PROTECT THE ENVIRONMENT THROUGH ENERGY EFFICIENCY (2003), *available at* http://www.energystar.gov/ia/partners/downloads/energy_star_report_aug_2003.pdf (describing the history and purpose of Energy Star).

117. "[T]he Market Transformation Programme warns that televisions are often set for display in shops, rather than the much lower levels of light needed for home use. It suggests that creating an 'eco-mode' for screen brightness could cut power consumption by 15%." *See* Sean Coughlan, *Do Flat-Screen TVs Eat More Energy?*, BBC News, Dec. 7 2006, *available at* http://news.bbc.co.uk/2/hi/uk_news/magazine/6188940.stm.

118. Larry Magid, *Putting Energy Hogs in the Home on a Strict Low-Power Diet*, N.Y. TIMES, June 4, 2007, at C12.

119. *Id.*

120. KAREN B. ROSEN & ALAN K. MEIER, LAWRENCE BERKELEY NAT'L LAB. REPORT LBNL-42393, ENERGY USE OF TELEVISIONS AND VIDEOCASSETTE RECORDERS IN THE U.S. 34 (1999); BENOI LEBOT, LAWRENCE BERKELEY NATIONAL LAB. REPORT LBNL-46019, GLOBAL IMPLICATIONS OF STANDBY POWER USE 1, *reprinted in* PROC. 2000 ACEEE SUMMER STUDY ON ENERGY EFFICIENCY IN BUILDINGS, ASILOMAR (2000).

Standby power constitutes around 5 to 7 percent of the average U.S. household's total electricity use and 10 percent for the average household in California, where there is a greater than average penetration of consumer electronics and home office equipment.[121] The electricity used by the average home in the United States produces 7.2 tons of CO_2 per year, while total domestic electricity consumption produces 935 million tons. Thus, standby consumption is responsible for 47 to 65 million tons of CO_2 per year.[122] If standby consumption can be reduced by one-third, this would reduce CO_2 emissions by 16 to 22 million tons.

Addressing standby power use effectively will require a combination of technology mandates, consumer education (for example, standardized energy consumption labeling), and behavior change. Standby power costs the average household \$48 to \$67 per year,[123] suggesting that so long as remedial measures fall below this level, they will generate cost savings for the individual. Policy interventions thus should target barriers that inhibit people from adopting cost-effective measures to reduce their standby power consumption.

The simplest way to address standby electricity consumption is to turn off devices when they are not in use. Many devices such as microwave ovens and televisions, however, do not have true "off" settings, but rather continue to draw power for clock displays, warming up internal components for instant on performance, or to respond to remote controls. In these cases, the owner may still achieve a true off condition by unplugging the device or

121. ALAN K. MEIER, LAWRENCE BERKELEY NAT'L LAB. PAPER LBNL-49377, A WORLDWIDE REVIEW OF STANDBY POWER USE IN HOMES 3 fig.1, tbl.2 (2001); J.P. Ross & A. Meier, *Measurements of Whole-House Standby Power Consumption in California Houses*, 27 ENERGY 861, 861 (2002).

122. The Energy Information Administration estimates that the average household uses 10,656 kilowatt hours (kWh) of electricity per year. *See* ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, RESIDENTIAL ENERGY CONSUMPTION SURVEYS: 2001 CONSUMPTION AND EXPENDITURES TABLES 3, tbl.CE1-1c (2002), *available at* ftp://ftp.eia.doe.gov/pub/consumption/residential/2001ce_tables/enduse_consump2001.pdf. Although the carbon intensity of electricity varies, the national average is 1.35 pounds of CO_2 per kWh consumed. *See* U.S. DEP'T OF ENERGY & U.S. ENVTL. PROT. AGENCY, CARBON DIOXIDE EMISSIONS FROM THE GENERATION OF ELECTRIC POWER IN THE UNITED STATES 2 (2000) [hereinafter DOE, EPA, CO_2 FROM ELECTRIC POWER], *available at* http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2emiss.pdf. Thus, the average household's electricity use produces 7.2 tons of CO_2 annually. Total residential electricity use produces 935 million tons of CO_2. *See* U.S. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2005, at 3-7, tbl.3-6 (2008) [hereinafter GHG EMISSIONS AND SINKS], http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf. Standby use produces 5 to 7 percent of this 935 million tons, or 47 to 65 million tons. *See supra* note 121 and accompanying text.

123. The cost of electricity is roughly \$0.09 per kilowatt hour. *See* ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DOE/EIA-0348, ELECTRIC POWER ANNUAL 2006, at 9 (2007). Thus, the average U.S. household pays around \$960 per year for electricity, and 5 to 7 percent of \$960 is \$48 to \$67. *See supra* note 121 and accompanying text.

using a switchable power strip. Yet this entails a degree of inconvenience that may well deter energy-saving behavior changes.

A combination of recent advances in technology and regulatory requirements or market pressure could overcome these barriers. Many devices draw substantial power—tens of watts—in standby mode, but it is almost always possible to design them to draw one watt or less. Mandating a one-watt-maximum for standby power consumption could cut standby power by 68 percent, or 32 to 44 million tons of CO_2 annually.[124] The EPA's voluntary Energy Star standards now specify a 1-watt-standby-draw,[125] and some manufacturers are aiming for 0.1 watts over the next several years.[126]

Another technological fix consumers can adopt if their appliances do not meet the low-standby-power criterion is automatic energy-saving power strips. Relatively inexpensive ($30–$60) power strips are now available that automatically switch power to their outlets on and off when a low-power motion sensor detects someone entering or leaving the room.[127] Power distribution units offer the convenience of turning appliances on and off by remote control.[128] Other smart power strips monitor the electric current drawn by a master device, such as a computer or a stereo amplifier, and automatically switch all the attached peripheral devices on and off appropriately.[129] Just a few of these power strips, strategically placed in the household, can greatly reduce leakage and reduce electricity bills as well.

If a household used three such power strips (reducing its standby power use by two-thirds), the electricity savings would repay the initial cost within

124. *See* Ross & Meier, *supra* note 121, at 867 (based on a study of ten California homes).

125. *See, e.g.*, ENERGY STAR® PROGRAM REQUIREMENTS FOR TVS, VCRS, DCR TVS WITH POD SLOTS, COMBINATION UNITS, TELEVISION MONITORS, AND COMPONENT TELEVISION UNITS ELIGIBILITY CRITERIA (Version 2.2), http://www.energystar.gov/ia/partners/product_specs/eligibility/tv_vcr_elig.pdf (specifying standby power of <1.0 Watt for TVs, VCRs, DVDs, and combination units as of July 1, 2005); ENERGYSTAR PROGRAM REQUIREMENTS FOR CONSUMER AUDIO AND DVD PRODUCTS, http://www.energystar.gov/ia/partners/product_specs/eligibility/audio_dvd_elig.pdf at 4 (specifying standby power of <1.0 Watt for products shipping after Dec. 31, 2002).

126. David Maciel, Sony and the Environment, presentation at the Energy Efficiency Stand-by Power Consumption Workshop, Mexico City, Sept. 25–26 2007, at 8, *available at* http://www.conae.gob.mx/work/sites/CONAE/resources/LocalContent/5343/1/DavidMaciel.pdf (concluding that Sony has a target of 0.1 watts of standby power consumption with a two-year lead time).

127. Manufacturers include Bits Ltd. and Wattstopper. *See* Tom Mainelli, *Brainy Power Strip*, PC WORLD, APR. 2003, at 66 (reviewing smart power strips); *see also* Umbra Fisk, *Strip Tease: On Power Strips*, GRIST, Nov. 5, 2007, http://www.grist.org/advice/ask/2007/11/05/index.html.

128. Remotely controlled power distribution units are sold by many manufacturers, such as Tripp-Lite. *See, e.g.*, TRIPP-LITE, INC., POWER DISTRIBUTION UNIT SELECTION GUIDE, TECHNICAL APPLICATION BULLETIN #95-2893 (2008), *available at* http://www.tripplite.com/shared/pdf/literature/200710208.pdf.

129. Mainelli, *supra* note 127.

five years.[130] Consumers' extremely high discount rates for long-term savings from one-time purchases tend to serve as a barrier, however, to economically favorable investments in energy-saving devices.[131] Thus, public interventions in the form of education, incentives, or technology mandates may be desirable.[132]

Because standby power use is largely invisible, making information about cost of ownership available to consumers at the time of purchase may have a significant effect on behavior. A study by Lawrence Berkeley National Laboratory found that the EPA's voluntary Energy Star labeling program has produced changes in purchasing that reduce electricity bills by billions of dollars a year. The changes also reduce CO_2 emissions by tens of millions of tons per year.[133]

Despite the prospect of reducing standby power through purchases of more efficient equipment, daily behavior changes may be the most efficient approach in some cases. Small external power supplies used to charge handheld electronics, such as cell phones, music players, and batteries for power tools, draw power while plugged in, even when the device is not charging. New technology chargers that sense whether they are being used and switch into a low-power sleep mode are now available at low enough cost to be competitive when reduced electric bills are considered.[134] Greater reductions

130. Standby use costs $48 to $67 per year, *see* discussion *supra* notes 122–123 and accompanying text. Much of the standby power is concentrated in media centers and personal computer centers or home offices see *supra* notes 115, 118, 119, 120. Thus, it is reasonable to estimate that three smart power strips controlling a combination of media centers and personal computer centers would significantly reduce total standby power consumption by as much as two-thirds. Saving two-thirds of this total yields a range of $32 to $45 per year. Three smart outlet strips at $30 to $60 would cost $90 to $180—an amount that would be recouped in 3 to 5.5 years.

131. *See* NRC, HUMAN DIMENSION, *supra* note 13, at 36–42.

132. For inconsistent accounting, see Loewenstein and Prelec, *supra* note 103, at 137–38. Consumers are often reluctant to pay up front for energy-saving appliances or devices even when reduced energy bills will repay the initial investment at very favorable terms. *Id.* Interventions targeted at this reluctance should be an important part of this program. Well-designed interventions have proved effective at encouraging adoption of compact fluorescent lights, *see* discussion *infra* Part II.B.3, so we are optimistic in this regard.

133. C.A. Webber et al., *Savings Estimates for the ENERGY STAR Voluntary Labeling Program*, 28 ENERGY POL'Y 1137, 1144 tbl.4, 1148 fig.1 (2000). This article concludes that in 2000, total energy savings were $2.5 billion and carbon emissions were reduced by 6.7 million tons, which translates to 25 million tons of CO_2. *Id.* at 1142 tbl.3. By 2010, the article forecasts CO_2 emissions reductions of 20 million tons per year of carbon, equivalent to 73 million tons of CO_2. *Id.* at 1146, tbl.6. These figures assume market penetration limited to a "target" population that is receptive to Energy Star labeling. *Id.* If one hundred percent penetration were achieved, the emission reductions would be more than twice as large. *Id.* at 1148 fig.1.

134. *See, e.g.*, Rich Fassler, Recent Advances in Reducing Standby Power, Presentation at the Energy Efficiency Stand-by Power Consumption Workshop, Mexico City, Sept. 25–26 2007, at 8, *available at* http://www.conae.gob.mx/work/sites/CONAE/resources/LocalContent/5343/1/RFassler.pdf

in consumption can still be achieved, however, by unplugging the charger altogether when it is not in use. Nokia has introduced a cell phone that alerts its user to unplug the charger when the phone is fully charged.[135] Further research is needed to determine whether it is more efficient to educate consumers to unplug unused chargers or to focus on hastening the adoption of more efficient and smarter chargers.

Whatever the optimum blend of public interventions, if it is possible to cut standby consumption by two-thirds in half of the households in the United States (one-third of total U.S. standby consumption), we calculate resulting emissions reductions of 16 to 22 million tons of CO_2.[136] If a $100 million program of public education and subsidies for purchasing energy-saving devices achieved these savings, the cost would be $4.55 to $6.25 per ton.

In addition, once people start reducing wasteful standby electrical use, they may pursue other opportunities to reduce their electricity consumption. In particular, immediate feedback can reinforce effective behavioral changes. It appears that when consumers are provided with clear information about energy consumption, they often change their behavior to reduce their environmental impact and to save money. A number of studies have found that when people have easy access to real-time measurements of their energy use, they cut their use by 5 to 15 percent,[137] which corresponds to 0.36 to 1.1 tons of CO_2 per household per year. If one-third of U.S. households adopted real-time energy monitoring and reduced energy consumption by 5 to 15 percent, this would reduce CO_2 emissions by 16 to 48 million tons per year in the United States.

(describing power supplies that reduce standby consumption tenfold while only adding pennies to the retail cost).

135. Dave Waller, *Greening Your Mobile*, MANAGEMENT TODAY, Apr. 1, 2007, at 14; *see also* Nokia Launches Mobile Phones With Energy-Saving Alerts, TELECOMMWORLDWIRE, May 10, 2007.

136. *See supra* note 122.

137. *See* SARAH DARBY, ENVTL. CHANGE INST., OXFORD, THE EFFECTIVENESS OF FEEDBACK ON ENERGY CONSUMPTION: A REVIEW FOR DEFRA OF THE LITERATURE ON METERING, BILLING, AND DIRECT DISPLAYS 3 (2006); Tsuyoshi Ueno et al., *Effectiveness of an Energy-Consumption Information System on Energy Savings in Residential Houses Based on Monitored Data*, 83 APPLIED ENERGY 166, 181 (2006) (concluding that real-time feedback helped users to cut household power use by 9 percent through measures such as unplugging appliances or manually putting them into low-power modes); *see also* Steve Lohr, *Digital Tools Help Users Save Energy, Study Finds*, N.Y. TIMES, Jan. 10, 2008, at C1 (reporting on results of a study in Seattle, Washington, that found a 10 percent reduction in household utility bills following installation of devices that allow household monitoring and adjustment of electricity use).

Home energy monitoring devices are commercially available for \$30 to \$300 depending on the range of features.[138] Many utility companies subsidize the purchase or offer monitors free to their customers as part of time-of-use billing or other programs to manage demand during peak use periods.[139] Other entrepreneurs are promoting extremely sophisticated (and much more expensive) approaches to home energy monitoring that provide detailed information about energy use on a per-room or even a per-appliance basis.[140]

If a system purchased and installed for \$300 allowed a homeowner to reduce household electricity consumption by 10 percent, the system would repay the initial investment in slightly more than three years.[141] The cost of the meter could be amortized over three years at an annual cost of \$100. The \$100 would be offset by \$96 in annual electricity savings if the household achieved a 10 percent cut in use, so the net cost of 0.7 tons of annual CO_2 reduction would be \$4 per year, or \$6 per ton. If the meter functions well beyond the three-year payback period, the net cost per ton will be significantly negative. If one-third of U.S. households participated in a program such as this, the total emissions reductions (10 percent from one-third of households) would be 31 million tons.[142]

To overcome the differential accounting anomalies that deter individuals from purchasing such devices, a public program operated in partnership with electric utilities might supply electricity monitors on a rent-to-own basis with the payments charged to consumers' power bills. In this way, consumers could see the cost of the meter being repaid by lower electric bills. In addition, just as research on reducing automobile idling found that it was most effective to combine public education with laws restricting excessive idling, home electricity consumption may be most effectively reduced when feedback on consumption is combined with tangible rewards

138. *See* DARBY, *supra* note 137, at 11; *see also* Power Meter Store, Power Use Monitors, http://www.powermeterstore.com/c550/power_use_monitors.php (listing current U.S. prices).

139. Rebecca Smith, *Letting the Power Company Control Your AC*, WALL ST. J., Jul. 10 2007, at D1.

140. *See* Sharon Simonson, *Utility Monitoring Adds Up Power of Information*, SAN JOSE BUS. J., Aug. 31, 2007, at http://sanjose.bizjournals.com/sanjose/stories/2007/09/03/story3.html; Agilewaves, Inc, http://www.agilewaves.com (last visited July 15, 2008).

141. The average household pays about \$960 per year for electricity. *See supra* note 123. Ten percent of the \$960 per year (\$96 per year) would repay a \$300 investment in 3.1 years. For such a short period, we neglect pure time preference, discounting of the future value of money, and the inflation of electricity rates (in any event, the latter two would at least partially cancel each other out).

142. Total residential electricity use produces 935 million tons CO_2. *See* GHG EMISSIONS AND SINKS, *supra* note 122. If one-third of U.S. households reduced electricity consumption by 10 percent, this would reduce total emissions by 3.3 percent of 935 million tons, or 31 million tons.

for achieving energy saving targets. A recent review of the literature suggests that there is a useful synergy in combining real-time feedback with well-defined goals and tangible rewards for meeting those goals.[143]

In sum, if we assume that expenditures of $100 million for some mix of subsidies and other targeted interventions will induce 33 percent reductions in standby power use, and that one-seventh of the cost of the general public information campaign attributable to this intervention is $114 million, then the total out-of-pocket government cost is $214 million. If the resulting emissions reductions are 16 to 22 million tons, then the cost to the government per ton of CO_2 reduced are $10 to $13. The aggregate annual savings to households from reduced energy use are $2 to $3 billion, however. As a result, the total out-of-pocket government cost of $214 million would be significantly less than the total savings of $2 to $3 billion per year; the program would reduce CO_2 emissions by millions of tons at a significantly negative net national economic cost.

3. Accelerate Adoption of CFL Bulbs

The individual action that has attracted perhaps the greatest attention to date is the purchase and substitution of compact fluorescent light bulbs (CFLs) for the common incandescent light bulbs (ILs) in homes.[144] Our analysis supports this focus on CFLs; CFL substitution is certainly one of the easiest and most effective actions that individuals can take to reduce CO_2 emissions. Further, the retail industry has joined the substitution campaign enthusiastically. For example, Wal-Mart set a goal of selling 100 million CFLs in 2007 and ultimately surpassed its goal.[145] Government programs also promote substitution, including the well-publicized "Change a Light, Change the World" program,[146] and the "18seconds.org" campaign.[147] Legislation to ban ILs has been adopted in other coun-

143. *See* G. Wood & M. Newborough, *Energy-Use Information Transfer for Intelligent Homes: Enabling Energy Conservation With Central and Local Displays*, 39 ENERGY & BUILDINGS 495, 498 (2007) (noting that adding reward, either as a small monetary rebate or feedback emphasizing savings in electricity bills, can cut energy consumption by up to 19.4 percent).

144. *See* Charles Fishman, *How Many Light Bulbs Does it Take to Change the World? One. And You're Looking at It*, FAST COMPANY, Sept. 2006, at 74.

145. *See* Wal-Mart, Press Release, Wal-Mart Surpasses Goal to Sell 100 Million Compact Fluorescent Light Bulbs Three Months Early (Oct. 2, 2007), *available at* http://www.walmartfacts.com/articles/5328.aspx.

146. *See* ENERGY STAR, ENERGY STAR Change a Light Change the World Campaign 2007–2008, http://energystar.gov/index.cfm?c=change_light.changealight_index (last visited July 14, 2008).

147. *See* 18Seconds, http://www.18seconds.org (last visited June 15, 2008).

tries,[148] and recently enacted federal energy legislation will phase out most ILs and other inefficient bulbs by 2014.[149]

CFL substitution is attractive from numerous perspectives. Household lighting is responsible for about 70 to 160 million tons of CO_2 emissions per year.[150] About 90 percent of household lighting is performed by ILs, which convert only 5 percent of their input power to visible light.[151] CFLs typically consume only 25 percent—as much electricity as an equally bright IL.[152] Thus, replacing all residential ILs with CFLs has the potential to reduce CO_2 emissions by roughly 50 to 120 million tons per year at negative net cost to consumers.[153]

According to industry figures, roughly 3.1 billion light bulbs are in use in U.S. households today.[154] The amount of CO_2 emissions saved by changing a single light bulb depends on how many hours per day that bulb is

148. For example, Australia, Cuba, Ireland, and Venezuela have pending bans on incandescent light bulbs. *See Energy Efficiency Lighting: Hearing Before the S. Comm. on Energy and Natural Res.*, 110th Cong. 23–35 (2007) (statement of Paul Waide, Senior Policy Analyst, Energy Efficiency and Environment Division, International Energy Agency, Paris, France).

149. H.R. 6, 110th Cong. § 321 (2007) (providing that incandescent light bulbs will be phased out over a two-year period from 2012 to 2014, and that by 2014 a minimum energy-efficiency standard will apply to almost all general purpose lighting).

150. Annually, 101 billion kilowatt hours (kWh) of energy are consumed to produce residential lighting; this amounts to 8.8 percent of household electricity use. ENERGY INFO. ADMIN., U.S. HOUSEHOLD ELECTRICITY REPORT, fig. US-1 (2005), http://www.eia.doe.gov/emeu/reps/enduse/er01_us_tab1.html. Using the conversion factor of 1.35 pounds of CO_2 emissions per kWh of electricity, we calculate CO_2 emissions due to residential lighting of 68 million tons. *See* DOE, EPA, CO_2 FROM ELECTRIC POWER, *supra* note 122. An alternate calculation gives a larger figure of 156 million tons. *See supra* note 43.

151. Jeff Johnson, *The End of the Light Bulb*, 85 CHEMICAL & ENGINEERING NEWS, Dec. 3, 2007, at 46, 49.

152. Press Release, Dep't of Energy & Envt'l Prot. Agency, EPA and DOE Spread a Bright Idea: Energy Star Light Bulbs Are Helping to Change the World, (Jan. 15, 2008), *available at* http://www.doe.gov/news/5825.htm (noting that "Energy Star qualified [compact fluorescent light bulbs (CFLs)] use about 75% less energy and last up to ten times longer than incandescent bulbs"); *see also* ENERGY STAR PROGRAM REQUIREMENTS FOR CFLS (2003), *available at* http://www.energystar.gov/ia/partners/product_specs/program_reqs/cfls_prog_req.pdf (containing detailed energy efficiency requirements for Energy Star ratings for CFLs).

153. Household lighting produces roughly 70 to 160 million tons of CO_2 per year. *See* ENERGY INFO. ADMIN., *supra* note 122. Switching to CFLs would reduce this by 75 percent, or roughly 50 to 120 million tons. EPA reports that using CFLs in place of ILs used as little as 15 minutes per day will pay back the cost of the CFL in 3.6 years or less and yield a lifetime savings of $17 or more over ILs. The more hours a light is used per day, the shorter the payback and the greater the net savings. DEP'T OF ENERGY & ENVTL. PROT. AGENCY, LIFE CYCLE COST-ESTIMATE FOR ENERGY STAR QUALIFIED COMPACT FLUORESCENT LAMP(S) (2008), http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCFLs.xls.

154. *See Energy Efficient Lighting for a Brighter Tomorrow Act of 2007 (S. 2017), Hearing Before the S. Comm. on Energy and Natural Res.*, 110th Cong. 35–40 (2007) (statement of Kyle Pisto, VP of Governmental Relations, National Electrical Manufacturers Association) [hereinafter *Hearing*].

operated, the climatic conditions,[155] and the fuel source for the electricity used by the bulb. Detailed studies of residential lighting find that around one-quarter of household lights are used four or more hours per day, and that the typical light that a consumer would replace with a CFL is a 75 watt bulb used 6.7 hours per day.[156] Replacing this typical bulb with a CFL would reduce CO_2 emissions by about 190 pounds per year.[157]

Unlike many other emissions-generating technologies, light bulb turnover is quite rapid. The common IL has a life of only 1,000 hours, so CFLs can be substituted quickly, and they produce significant short-term emissions reductions.[158] Further, CFL prices have dropped dramatically in the past few years, and consumers are now able to purchase these bulbs for less than $3 per bulb.[159] This means the CFL payback to the consumer will occur within months after purchase.[160]

Despite all of these benefits and the recent federal law phasing out many IL bulbs,[161] a substantial opportunity for emissions reductions remains. Sales of CFLs have only recently taken off in the United States. The EPA reports that 290 million CFLs were sold in 2007, doubling the volume sold the previous year.[162] Still, CFLs constitute slightly less than 20 percent of all light bulb sales in the United States. Less than 10 percent of the 1.7 billion light bulbs sold in 2006 were CFLs (compared with 50 percent in Germany and 80 percent in Japan).[163] Many consumers in the United States

155. In winter or in cold climates, waste heat from ILs contributes to space heating, so savings from substituting CFLs would be partially offset by the increased load on the furnace. On the other hand, in summer or in hot climates, IL waste heat is unwelcome, and substituting CFLs can have a significant secondary impact in reducing the load on air conditioners. *See, e.g.*, NICOLAS LEFEVRE ET AL., INT'L ENERGY AGENCY, BARRIERS TO TECHNOLOGY DIFFUSION: THE CASE OF COMPACT FLUORESCENT LIGHTS 10 (2006).

156. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, RESIDENTIAL LIGHTING: USE AND POTENTIAL SAVINGS tbls. 4.18–4.19 (1996) [hereinafter EIA, RESIDENTIAL LIGHTING].

157. A 75-watt CFL bulb used year-round for 6.7 hours per day consumes 180 kilowatt hours. The consumption of one kilowatt hour corresponds with the production of 1.35 pounds of CO_2. *See supra* note 122. Thus, on average a single CFL results in 250 pounds of CO_2 emissions each year. Replacing the 75-watt IL bulb with an 18-watt CFL bulb would reduce CO_2 emissions by 75 percent, or 190 pounds per year.

158. *See* Fishman, *supra* note 144, at 76 (approximately 40 percent of the light bulb stock is changed in a year).

159. *See* Johnson, *supra* note 151, at 48. Wal-Mart currently sells brand name CFLs for as little as $1.65 per bulb. *See* Wal-Mart, GE CFL Light Bulb, http://www.walmart.com/catalog/product.do?product_id=5650617 (last visited July 14, 2008).

160. ENERGY INFO. ADMIN., *supra* note 156, at 13, fig. 3.2 (concluding that a $22 CFL would repay its purchase price in about 18 months at $0.10 per kilowatt hour, so a $3 CFL at $0.09 per kilowatt hour would repay its purchase price in less than three months).

161. *See supra* note 149.

162. Press Release, *supra* note 152.

163. *See Hearing*, *supra* note 154, at 35 (testimony of Kyle Pister).

still choose ILs at $0.50 a bulb instead of paying $3 per bulb for CFLs, despite the fact that the CFL will typically reduce electric bills by around $12 per year and avoid around $1.50 spent replacing an IL bulb three times per year.[164] Individuals are inordinately aware of initial costs but only vaguely aware of the lifetime savings associated with CFLs.[165] Moreover, CFLs are not perfect substitutes for ILs. Most do not have dimmer capabilities; the color of the light can vary significantly from ILs; CFL floodlights for recessed ceiling fixtures can take several minutes to come to full brightness; and CFLs contain minute amounts of mercury, necessitating special end-of-life handling and disposal.[166] Some also claim that long CFL life projections have yet to be borne out in practice.[167] This indicates that CFLs will continue to require a concerted public campaign in order to encourage ongoing adoption.

Fortunately, a wealth of research exists on the barriers to CFL adoption and the best practices for encouraging CFL adoption.[168] Important barriers to greater CFL adoption include: lack of information about the quality of particular brands of bulbs; unavailability of CFLs;[169] comparatively high purchase

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164. Replacing a 75 watt IL that is on 6.7 hours per day with an equally bright CFL reduces electricity use by 0.377 kWh per day (three-quarters of 0.075 kWh times 6.7 hours). At $0.09 per kWh, see *supra*, note 123, this amounts to savings of $0.034 per day, or $12.4 per year. *See* EIA, RESIDENTIAL LIGHTING, *supra* note 156, at 12 ("[A]n incandescent bulb lasts about 3.5 months.").

165. *See* ENERGY STAR, Compact Fluorescent Light Bulbs, http://energystar.gov/index.cfm?c=cfls.pr_cfls (last visited July 14, 2008) (noting that each CFL saves about $30 or more in electricity costs over each bulb's lifetime).

166. L.J. SANDAHL ET AL., PAC. NW. LAB. REPORT # PNNL-15730, COMPACT FLUORESCENT LIGHTING IN AMERICA: LESSONS LEARNED ON THE WAY TO MARKET 5.6–5.7 (2006); Blaie Harden, *Fluorescent Bulbs Are Known to Zap Domestic Tranquility*, WASH. POST, Apr. 30, 2007, at A1; EPA FREQUENTLY ASKED QUESTIONS: INFORMATION ON COMPACT FLUORESCENT LIGHT BULBS (CFLS) AND MERCURY (2008), *available at* http://energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf.

167. Andrew C. Revkin, *The Upside and Downside of Low-Energy Lighting*, N.Y. TIMES blog site (Dec. 7, 2007), http://dotearth.blogs.nytimes.com/2007/12/07/experiences-with-next-generation-lighting (reporting that the author, a New York Times reporter, experienced a "huge variability in the reliability of bulbs, with some CFLs burning out ridiculously quickly" in his home).

168. *See, e.g.*, KENNETH JAMES ET AL., PAC. GAS & ELEC., NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY: VOLUME R1-RESIDENTIAL LIGHTING BEST PRACTICES REPORT (2004); SANDAHL ET AL., *supra* note 166; LISA A. SKUMATZ & OWEN HOWLETT, FINDINGS AND "GAPS" IN CFL EVALUATION RESEARCH: REVIEW OF THE EXISTING LITERATURE (2006), http://mail.mtprog.com/CD_Layout/Day_2_22.06.06/1115-1300/ID109_Skumatz3_final.pdf; LEFEVRE, *supra* note 155.

169. CFLs have only recently become widely available at big-box stores, such as Home Depot, and are even less available at supermarkets, where most light bulbs are purchased. SANDAHL ET AL., *supra* note 166, at 2.4 ("Americans typically purchase light bulbs at grocery stores; however, until recently it was not likely that CFLs could be found there in any significant numbers or at competitive prices."); *id.* at 2.8 ("Even in 2006 many grocery, drug, and small hardware stores carry only a limited variety of bulbs." (citation omitted)); *id.* at 5.2 (reporting that in 2002, big-box stores had recently begun to stock inexpensive CFLs as a standard promotional item).

cost; undervaluing of savings in electricity costs; poor retail practices;[170] and skepticism about claims of energy savings, long life, and environmental benefits.[171] In addition, Lisa Skumatz and Owen Howlett note that almost half the benefit to the consumer of adopting CFLs may arise from benefits other than reduced energy cost.[172] These benefits, which include personal satisfaction and recognition by peers for caring for the environment, may not be exploited fully by incentive campaigns that focus only on reducing electricity bills.[173]

The most successful interventions have identified the important barriers to adoption by the target population and combined different approaches to address consumers' objections or hesitance. A number of campaigns between 2000 and 2002 focusing on reducing peak electricity load were very successful, producing benefits up to eight times the cost of the program.[174] Serious limitations exist to these interventions, however. The programs targeted large numbers of households, with budgets ranging from $0.62 to $5.50 per household, and induced 1 to 10 percent of those households to buy CFLs during a given year.[175] Most of the calculated benefits from these programs related not just to the reduction of greenhouse gas emissions, but to the reduction of load on strained electrical distribution systems (consumer savings on electricity bills was not accounted for).[176] More recent programs to promote

170. For example, failing to display and stock energy-efficient products in ways that make it easy for interested customers to locate and select products.

171. JAMES ET AL., *supra* note 168, at 19, exhibit R1-2; SANDAHL ET AL., *supra* note 166, at 2.1–2.9.

172. SKUMATZ & HOWLETT, *supra* note 168, at 9 (noting that consumers value nonenergy benefits up to 90 percent as much as the reduced electricity bills, so up to 47 percent of the total benefit is not cost driven).

173. *Id.*

174. Successful programs have used varied incentives, depending on the market, which include rebates to consumers, coupons or free samples distributed to consumers, and rebates to retailers to stock and sell CFLs. Best practices, as defined by a retrospective evaluation by JAMES ET AL., *supra* note 168, exhibit R1-E2 at 4, include the use of multiple incentives, careful choice of incentives based on market research, and careful performance monitoring to facilitate assessment and to reduce free riding. Benefit/cost ratios ranged from 1.6 to 8.3. *Id.* at R1-37, exhibit R1-7. Higher scores are better and a score of one corresponds to a neutral or indifferent outcome. GOVERNOR'S OFFICE OF PLANNING AND RESEARCH, STATE OF CAL., CALIFORNIA STANDARD PRACTICE MANUAL: ECONOMIC ANALYSIS OF DEMAND-SIDE PROGRAMS AND PROJECTS 27 (2002) (describing benefit-cost tests for reducing electricity demand).

175. *Id.* at 12.

176. If only the CO_2 reductions are counted, these interventions cost somewhere between $9 and $48 per ton of CO_2, but this is a misleading figure because reducing CO_2 emissions was not the goal of any of these programs. *See* JAMES ET AL., *supra* note 168, at 12. Program effectiveness was measured in dollars per kilowatt hour reduced in the first year. The latter ranged from $0.06 to $0.19. *Id.* at 37 exhibit R-7. Over the expected lifetime of the CFL (5.8 to 9.4 years, see *supra* note 167) the cost per kilowatt hour reduced falls to between $0.01 and $0.03. *See id.* at 12. One kilowatt

CFL adoption have achieved much greater penetration. For example, a program in British Columbia raised the fraction of households with at least one CFL from 26 percent in May 2002 to 55 percent in January 2004. Additionally, utility-sponsored programs in Massachusetts and Connecticut increased CFL sales by 670 percent between 2002 and 2005 and raised the fraction of households with one or more CFLs to over 60 percent, although further work is needed to increase the number of CFLs per household.[177]

We believe that a new generation of national CFL promotion could be significantly more cost-effective. First, the major barriers against which previous programs have struggled—price and availability—have dropped quite dramatically in the last few years. CFL prices have dropped from around $6 per bulb at the time of the interventions studied (2000–2002) to around $2 today.[178] Moreover, at the time of the studies, CFLs were much less widely available at common retail outlets, while today they are readily available at common big-box stores and are increasingly available even at supermarkets.[179] The lower barriers, combined with effective use of lessons-learned from past campaigns, suggests that a $100 million national campaign with a clear focus on reducing greenhouse gas emissions rather than on peak load could be more cost effective.

For example, if Wal-Mart is able to sell 100 million CFLs at around $2.00 each, it must be able to do so while spending much less than one dollar per bulb on marketing. If a $150 million public campaign, with a mixture of publicity, consumer education, and incentives to retailers, were similarly effective, it might be able to place 100 to 300 million bulbs in homes. CO_2 emissions would thereby be reduced by 10 to 30 million tons per year.[180] Estimates of average CFL lifetime range from 5.8 years to 9.4 years in practice,[181] so lifetime

hour of electricity produces, on average, 1.35 pounds of CO_2, so we calculate $9 to $48 per ton. *See* DOE, EPA, CO_2 FROM ELECTRIC POWER, *supra* note 122.

177. SANDAHL ET AL., *supra* note 166, at 5.5–5.6. Detailed analysis of the cost-effectiveness of these programs is not available.

178. SANDAHL ET AL., *supra* note 166, at 2.2 (concluding that the average price in 2003 was $6.00 per bulb, and that many consumers polled at the time cited $2.00 as a significant threshold below which they would be much more eager to buy CFLs).

179. Don Alaimo, *Less Is More: Energy-Saving Compact Fluorescent Bulbs Are Helping Spark The Lighting Category Along With High-End Decorative Specialty Products*, SUPERMARKET NEWS, Oct. 2, 2006, at 49 (noting that "[i]n the past year, compact fluorescent lights have been a top growth area of lighting for Price Chopper").

180. Because consumers preferentially replace heavily-used bulbs with CFLs, we adopt the U.S. Department of Energy's typical bulb for these calculations. *See supra* note 157 (noting that replacing a typical 75 watt IL bulb with an 18 watt CFL bulb reduces CO_2 emissions by 190 pounds per year).

181. SKUMATZ & HOWLETT, *supra* note 168, at 7; LISA A. SKUMATZ & JOHN GARDNER, SKUMATZ ECONOMIC RESEARCH ASSOCIATES TO SOUTHERN CALIFORNIA EDISON, REVISED/UPDATED EULS BASED ON RETENTION AND PERSISTENCE STUDIES RESULTS 8–9 (2005) (concluding

emissions reductions would be in the range 55 to 270 million tons, and the cost effectiveness of the program would be $0.56 to $2.70 per ton.

In sum, if we assume that the out-of-pocket cost to the government for subsidies to induce acceleration of CFL adoption by 100 to 300 million bulbs is $150 million plus three-fourteenths of the cost of the public information campaign ($170 million), then the total government cost is $320 million. If the emissions reductions are 55 to 270 million tons over the lifetime of the bulbs, the costs to the government per ton of CO_2 reduced are $1 to $6 per ton. The public would spend $200 to $900 million purchasing the CFLs but would save $7.2 to $34 billion over the lifetime of the bulbs from reduced energy use.[182] As a result, the total national cost of $520 to $1.2 billion would be significantly less than the total national savings of $7.2 to $34 billion, and the program would therefore reduce CO_2 emissions by hundreds of millions of tons at a significantly negative net cost.

4. Adjust Household Thermostat Settings Two Degrees in Summer and Winter

The largest gains from heating and cooling will arise from replacing existing equipment with new high-efficiency furnaces and air conditioners, but such purchases require major financial outlays and hence cannot be considered a low-hanging fruit option. Most households, however, can simultaneously reduce CO_2 emissions and save money by making minor thermostat adjustments in both winter and summer. As shown in Figure 1, space heating and cooling is the largest component of household CO_2 emissions, and small changes therefore can produce appreciable results.

Indoor thermal comfort appears to be both a very personal and culturally-determined preference.[183] International studies have shown, for example, that citizens in countries with similar incomes and energy prices choose strikingly different indoor temperatures in their homes.[184] Overall, however, average indoor temperatures in winter have increased over time,

based on a review of 100 empirical studies that the lifetime of residential use CFLs should be revised upward to 9.4 years for indoor use and 7.1 years for outdoor use).

182. This results in a savings of $12.40 per year per bulb, $72 to $117 over the life of the bulb, or $7.2 to $35 billion for 100 to 300 million bulbs (for example, $117 per bulb times 300 million is $35.1 billion). *See supra* note 164.

183. See NRC, HUMAN DIMENSION, *supra* note 13, at 47–48.

184. ENERGY BUSINESS INTELLIGENCE, E SOURCE SPACE HEATING ATLAS ch.2 (2004). To illustrate, see *infra* notes 192–193, and accompanying text.

probably due to a more sedentary lifestyle and a decreasing willingness to use clothing as insulation in the winter.[185]

We believe a modest two degree Fahrenheit (F) change in ambient indoor temperatures, combined with a more significant reduction in overnight winter temperatures, does not constitute a significant lifestyle adjustment. The range of annual savings derived from a two-degree F change in summer and winter temperatures runs from 1,000 to 2,000 pounds of CO_2 per household,[186] depending on the source of the energy used for home heating and cooling, the efficiency of existing equipment, current temperature settings, and other factors. This temperature change could result in household savings of as much as $125 per year without any offsetting financial costs.[187]

Despite the clear financial gains that households can reap from pursuing this option, there almost certainly will be some pushback from citizens who have grown accustomed to existing temperature settings. Many older Americans will remember the dismal results of President Carter's attempt to convince the nation's citizens that they should turn down the thermostat and rely on more layers of clothing.[188] Until perceptions shift in the general public about the threat posed by climate change, actions that are seen as asking Americans to sacrifice have uncertain prospects.

It is important, therefore, to launch an effort that combines an attractive informational component with some level of subsidy for the individual household. This subsidy could come in the form of a $10 coupon for the purchase of a programmable thermostat, or it could take the form of a coupon for a meter that monitors household energy use. The programmable thermostat would be helpful in relieving daily attention to temperature setting. Programmable thermostats can be purchased for as little as $50.[189] Meters that provide residents with quantitative evidence of energy use would be helpful in providing important feedback to households. After all, monthly bills do not provide real-time feedback, and research has shown that real-time feedback

185. *Id.*

186. For the 2,000 pounds per year calculation, see An Inconvenient Truth, Reduce Your Impact at Home, http://www.climatecrisis.net/takeaction/whatyoucando (last visited July 14, 2008). The 1,000 pounds per year estimate is the result of calculations derived from data at GreenerChoices.org, Solutions at Home, http://greenerchoices.org/globalwarmingathome.cfm (last visited July 14, 2008).

187. This calculation assumes a 5 percent decrease in heating costs and a 10 percent reduction in cooling costs, leading to reductions of $63 and $62, respectively. Nashville Electric Service, *Powernotes*, August 2007.

188. David Morris, *Carter's Brave Vision on Energy*, MINNEAPOLIS STAR TRIB., Oct, 10, 2005, at A10.

189. *See Five Ways to Go Green From Al Gore*, CNN.COM (Aug. 24, 2007), http://www.cnn.com/2007/LIVING/wayoflife/08/23/o.green.gore/index.html.

can result in energy savings of 5 to 15 percent.[190] Meters that not only measure electricity use, but also natural gas use, are not yet available on the consumer market, but they are being installed by some utilities, as well as being developed for consumer use.[191] If we assume that 10 million households will take advantage of the offer, the cost will be $100 million.

Japan already has launched an effort to get citizens to change their temperature settings. For the summer months, it has launched a "Cool Biz" campaign imploring citizens and businesses to set their indoor temperatures at 82 degrees F.[192] For the winter months, it has a "Warm Biz" effort designed to induce temperatures to be set at 68 degrees F. This campaign is decidedly more ambitious than the measure being advocated here, and it is too early to say whether it is having the intended effect.[193]

We assume that the combination of the general public information campaign and targeted subsidies will induce 33 percent of all households to make the two degree change in their thermostat settings. This means that we could expect to gain from 18.1 to 36.3 million tons of CO_2 emissions savings from this measure.[194] If we assume that the out-of-pocket costs to the government for thermostat adjustment interventions are $100 million plus one-seventh of the $1.5 billion cost of the public information campaign ($114 million), then the total cost is $214 million. If the emissions reductions are 18 to 36 million tons, the costs to the government per ton of CO_2 reduced are $6 to $12. The aggregate savings to households from reduced energy use are roughly $4.5 billion, however. As a result, the total national economic savings are over $4 billion, or between $110 and $150 per ton of CO_2 reduced.

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190. SARAH DARBY, ENVTL. CHANGE INST., THE EFFECTIVENESS OF FEEDBACK ON ENERGY CONSUMPTION 3 (2006).

191. PAUL WRIGHT, INFORMATION TECHNOLOGY FOR THE SUPPORT OF BEHAVIOR CHANGE IN ENERGY USAGE (2007).

192. The temperature-setting campaign is part of the Japanese government's effort to reduce emissions from the individual and household sector. The effort is termed "Team Minus 6%" to indicate that the goal is to reduce carbon emissions by 6 percent (equal to Japan's commitment to the Kyoto Protocol). For a description of the program, see Press Release, Ministry of the Env't, Gov't of Japan, Launching of National Campaign to Fight Global Warming "Team Minus 6%" (Apr. 28, 2005), *available at* http://www.env.go.jp/en/press/2005/0428b.html.

193. The temperatures are clearly a source of discomfort for many Japanese. *See* Sebastian Moffett, *Japan Sweats It Out as It Wages War on Air Conditioning*, WALL ST. J., Sept. 18, 2007, at A1.

194. We assume that one-third of all U.S. households (36.3 million) will take the desired measure. If we assume a conservative 1,000 pounds of CO_2 in annual household savings, and divide by 2,000 pounds to convert to tons, our resulting estimate is 18 million tons CO_2 of savings. If we assume a more aggressive 2,000 pounds per household, the result is 36 million tons.

5. Decrease Water Heater Temperature

Although it receives less attention than other actions, reducing CO_2 emissions associated with hot water heating is both very significant and easy to accomplish. The fact that household water heaters are kept out of sight may contribute to their relative neglect. Many hot water heaters are installed with a default temperature setting of 140–150 degrees F, when in most cases temperatures of 120 degrees F will be perfectly adequate to meet households' needs.[195] Individuals can adjust the temperature settings by themselves with only a small time cost and without any financial cost. The financial savings from reducing temperatures by 20 degrees F would be about $24 to $40 per year per household.[196]

Conservation advocates frequently suggest the purchase and installation of an insulating blanket to surround the water heater,[197] but upgrades in hot water heater insulation in recent years have rendered blankets of little use for models less than ten years old.[198] The expected lifetime of a water heater is about 10 years; thus, the number of units requiring a blanket is diminishing quickly, and we therefore did not include insulation in our selection of low-hanging fruit. CO_2 emissions vary between electric and natural gas water heaters, but a rule of thumb is that a setback of twenty degrees F could produce as much as 1,466 pounds of CO_2 emissions reductions per year.[199]

For the purposes of this analysis, we assume that the combination of the general public information campaign and targeted subsidies will induce 50 percent of U.S. households to take this action.[200] If half of all households do so, we can anticipate CO_2 emissions reductions of between 28 and 39 million tons.[201] The subsidies could take a wide range of forms. For example, in the

195. Power Scoreboard, Reduce Your Energy Consumption, Twenty Things You Can Do to Conserve Energy, http://www.powerscorecard.org/reduce_energy.cfm (last visited July 14, 2008).

196. The American Council for an Energy-Efficient Economy claims that each 10°F reduction will save 3 to 5 percent of water heating costs. *See* American Council for an Energy-Efficient Economy, *Consumer Guide to Home Energy Savings: Condensed Online Version*, http://www.aceee.org/consumerguide/waterheating.htm. Average yearly energy costs vary according to region and technology, figures provided by the Council, *see id.*, lead to a ball park average cost figure of $400 per year. A 20°F reduction, therefore, comes to between $24 to $40 in reduced costs.

197. *See Five Ways to Go Green From Al Gore*, *supra* note 189.

198. *See* GreenerChoices.org, *supra* note 186.

199. *See id.*

200. The recommended general public information campaign may need to include information that calms public fears about running out of sufficient hot water, or the subsidy may need to be reduced somewhat to pay for a separate, targeted public information campaign that addresses this concern.

201. We assume that half of all U.S. households (roughly 55 million, *see supra* note 62) will make this adjustment. If we conservatively estimate an annual savings of 1,000 pounds of CO_2 per household, we then multiply by 55 million households and convert to tons by dividing by 2,000

event individuals do not feel confident making the changes themselves, a $5 subsidy could be provided to gas and electric utilities for every customer they assist in making the change. If 20 million U.S. households (20 percent) opt for this service, the total subsidy will cost the government $100 million.

In sum, if we assume that the out-of-pocket costs to the government include $100 million for thermostat adjustment subsidies, plus one-seventh of the cost of the general public information campaign ($114 million), then the total cost is $214 million. If the emissions reductions are 28 to 39 million tons, the costs to the government per ton of CO_2 reduced are $6 to $8. The aggregate savings to households from reduced energy use are from $1.3 to $2.2 billion, however. As a result, the total savings to U.S. households run from $1 to $2 billion total, or between $25 and $70 per ton of CO_2 reduced.

6. Maintain Recommended Tire Pressure in Personal Motor Vehicles

As noted previously, personal vehicle use produces roughly half of all the CO_2 emissions over which individuals have substantial, direct control. In theory, then, large savings are available from measures directed at vehicle use.[202] Unfortunately, this does not translate into a plethora of low-hanging fruit actions, as we have defined them. Vehicle choices and vehicle driving styles are lifestyle decisions that will take considerable effort to alter, even with rising fuel prices.[203] In addition, vehicle driving style has become less, not more efficient in recent years, even leading the EPA to revise its motor vehicle fuel economy methodology.[204] Nevertheless, some individual actions are relatively painless and produce measurable savings, and we discuss two: tire pressure maintenance and, in the next subsection, air filter replacement.

The first of the two measures is simply to maintain tire pressure at manufacturers' suggested levels. The U.S. Department of Energy estimates that vehicle gas mileage improves an average of 3.3 percent by inflating tires

pounds. The result is 28 million tons. A more aggressive assumption of 1,400 pounds per household brings the total to 39 million tons.

202. Indeed, many have claimed that the driver is the biggest factor in the fuel economy achieved by any vehicle. The U.S. Department of Energy asserts that aggressive driving can reduce gas mileage by 33 percent on highways and 5 percent in cities. *See* U.S. Dep't of Energy, Driving More Efficiently, http://www.fueleconomy.gov/feg/driveHabits.shtml (last visited July 14, 2008). The potential remedies, however, do not qualify as low-hanging fruit actions.

203. *See* DAVID GREENE & ANDREAS SCHAFER, REDUCING GREENHOUSE GAS EMISSIONS FROM U.S. TRANSPORTATION 39 (2002).

204. *See* Vandenbergh & Steinemann, *supra* note 1, at 1727–28.

regularly to proper pressures.[205] Tire gauges are inexpensive, and routine oil changes often include tire inflation as a matter of course. The low-hanging fruit action is simply to get the U.S. public to check and maintain tire pressure on a consistent basis. A two-car family could save about $120 per year by taking this action.[206]

An effort will have to be mounted to increase public diligence in making this change. It is clearly not a task citizens currently embrace, considering the minimal attention required. In fact, studies suggest that roughly one-third of all personal motor vehicles have tires that are not inflated to recommended levels.[207] We assume that the combination of the general public information campaign and targeted subsidies will induce an additional one-third of the personal motor vehicle fleet in the U.S. to be maintained at proper tire pressure. For example, the subsidy could be in the form of sending households a tire pressure gauge. If 50 million gauges are distributed at a cost of $2 per gauge, the total cost will be $100 million. The one-third increase in proper tire inflation would translate into CO_2 savings of 12 million tons.[208]

In sum, if we assume that the out-of-pocket cost to the government for tire gauges is $100 million plus one-seventh of the cost of the public information campaign ($114 million), the total government cost is $214 million. If the emissions reductions are 12 million tons, the cost to the government per ton of CO_2 reduced is $18 for the first year of the program. If we can reasonably assume that many drivers will continue to maintain their tire pressure with little further incentive, however, the cost of the program, averaged over several years, will be less than $10 per ton. The aggregate savings to households from reduced energy use are $3.6 billion.[209] As a result, the total national savings are $3.4 billion, or $280 per ton of CO_2 reduced in the first year alone, with additional savings accruing in future years.

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205. U.S. Dep't of Energy, Energy Saver Tips on Saving Energy & Money at Home: Driving and Car Maintenance, http://www.eere.energy.gov/consumer/tips/driving.html (last visited July 14, 2008).

206. This calculation assumes savings of 40 gallons per vehicle per year at $3.00 per gallon.

207. Forty gallons is the difference between achieving an average gas mileage of 21 mpg and a 3.3 percent improvement (to 21.7 mpg). This calculation is based on the average U.S. household travel mileage per year of 25,000 miles. We calculate the dollars figure by multiplying 40 gallons times $3.00 per gallon of gas.

208. Americans consume roughly 113 billion gallons of gasoline annually in light duty vehicles. EIA, HOUSEHOLD VEHICLES, *supra* note 80. A 3.3 percent improvement in fuel efficiency would reduce consumption by 3.7 billion gallons. We only assume one-third of the vehicles will maintain proper pressure, so the savings amount to 1.2 billion gallons saved, equivalent to 12 million tons of CO_2.

209. This calculation assumes 1.2 billion gallons of fuel saved at $3 per gallon.

7. Change Air Filters in Personal Vehicles at Recommended Intervals

Few drivers perceive significant benefits from replacing automobile air filters, but replacing clogged filters can improve vehicle efficiency, lengthen engine life, and consequently save the owner money. Specialists recommend air filter changes every 12,000 to 15,000 miles, but it is doubtful that most drivers follow this schedule.[210] Changing an air filter is quite simple and can, in most cases, be done by the owner. Or the owner can have the filter replaced when periodic oil changes are required.

In most cases the purchase of an air filter from an auto supply store will run from $15 to $50, and we have assumed a midrange $30 price for our analysis.[211] Gasoline savings alone from changing an air filter at the recommended interval total about $240 per year.[212] As a result, it is cost effective for the individual to maintain a regular schedule for changing filters.

Periodic air filter changes can save the vehicle owner anywhere from 7 to 10 percent in fuel mileage.[213] This measure also can result in substantial CO_2 emissions savings. In fact, even if remedial measures only result in an additional one-fourth of all vehicles having their filters changed on an annual basis, 19 to 27 million tons of CO_2 will be saved.[214]

Despite the favorable economics, the public has demonstrated considerable lethargy when it comes to this measure. We assume that an ambitious public information campaign combined with a subsidy could enlist vehicle owners to service a quarter of all registered vehicles. A subsidy could occur in the form of a coupon that provides a $5 reduction in the price of what would otherwise be a $30 purchase. If coupons are used for 20 million filter purchases, the resulting cost would be $100 million.

In sum, if we assume that the out-of-pocket cost to the government for air filters is $100 million plus one-seventh of the cost of the public information

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210. The frequency is roughly once a year for most vehicles. Scott Memmer, How To Change Your Car's Filters, http://www.edmunds.com/ownership/howto/articles/43786/article.html (last visited July 14, 2008).

211. *See* Race Pages, http://www.racepages.com/parts/air_filter.html (last visited July 14, 2008).

212. The practice should save a two-car family 80 gallons per year, or $240 at $3 per gallon. Eighty gallons is the difference between achieving an average gas mileage of 21 mpg and a 7 percent improvement (to 23 mpg). This calculation is based on the average U.S. household mileage per year of 25,000 miles. We calculate the dollar figure by multiplying the 80 gallons times $3 per gallon.

213. The U.S. Department of Energy claims that this habit will save up to 10 percent in gasoline mileage. *See* U.S. Department of Energy, Keeping Your Car in Shape, http://www.fueleconomy.gov/feg/maintain.shtml (last visited July 14, 2008).

214. A 7 to 10 percent reduction by one-fourth of all households of the 113 billion gallons consumed annually in personal driving would save 2.0 to 2.8 billion gallons of fuel per year, equivalent to 19 to 27 million tons of CO_2. *See* EIA, HOUSEHOLD VEHICLES, *supra* note 80.

campaign ($114 million), the total government cost is $214 million, or $8 to $11 per ton of CO_2. We assume the net annual savings per household to be $190 ($240 in fuel savings minus $50 for the cost of two filters). The aggregate savings to participating households from this measure over five years are over $5 billion per year. As a result, the total national savings over five years are roughly $25 billion, or $925 per ton of CO_2 reduced.

C. Potential Aggregate Emissions Reductions

1. Total Emissions Reductions

Table 2 combines the quantitative results from our analysis of seven low-hanging fruit actions individuals can take to reduce CO_2 emissions.[215] The results range from a low of 111 million tons of emissions savings to a high of 182 million tons of emissions savings. If we take the mean of these two figures, we reach 147 million tons, which is a good match to the 7-in-5 target of 150 million tons. In other words, public behavior change regarding these seven measures stands a reasonable chance of meeting the ambitious target. It is also important to re-emphasize that the maximum values seen in Table 1 are not the results that would be obtained through full (100 percent) public behavior change. They are simply the results derived from plausible levels of participation in a voluntary program—in many cases, no more than a third of all households.

TABLE 2: ESTIMATED RANGE OF EMISSIONS REDUCTIONS

Measure	Low*	High*
1. Reduce Idling	6	9
2. Reduce Standby Power	16	22
3. CFL Substitution	12	37
4. Two Degree Temperature Change	18	36
5. Water Heater Temperature Changes	28	39
6. Tire Pressure Maintenance	12	12
7. Auto Air Filter Changes	19	27
Totals	111	182

*Numbers are in millions of tons CO_2, rounded to the nearest million.

In short, if started in 2009, the limited set of low-hanging fruit measures outlined in this Article can reasonably be expected to generate annual

215. One European study puts the range of negative marginal costs for several of the chosen measures at 10 to 90 euros per ton. VATTENFALL, *supra* note 31, at 6.

reductions in the neighborhood of 150 million tons of CO_2 by 2014. These emissions reductions would amount to roughly 7 percent of the total U.S. annual individual and household emissions as of 2005. The discussion above illustrates, however, that many of the individual and household emissions trends are heading in the wrong direction. Examples include increasing emissions attributable to aggressive driving habits, temperature settings for indoor heating and cooling, and electronics standby power use.[216] Thus, the emissions reductions we identify here are all the more important because the business-as-usual baseline looks grim in the absence of law and policy interventions.

2. Comparison to Other Targets

The magnitude of the 150 million ton reduction compares favorably to a number of benchmarks, both in terms of the volume and the speed by which they are accomplished. As mentioned at the outset, the reductions constitute 47.7 percent of the annual CO_2 emissions by the petroleum refiners in the United States and almost three times the CO_2 emissions generated annually by the aluminum industry.[217] The reductions also are roughly equivalent to the emissions from 26 million automobiles or 54 large power plants.[218]

The emissions reductions also compare favorably to the emissions reductions provided for in the leading academic and federal legislative emissions reduction proposals. In the academic literature, Pacala and Socolow have proposed a stabilization wedge concept for examining global emissions reductions. Pacala and Socolow argue that given the projected business-as-usual growth in CO_2 emissions on a global level, reductions of seven billion tons of carbon (which is equivalent to roughly 3.7 billion tons of CO_2) will be required to stabilize global emissions by 2054.[219] They propose fifteen sets of actions that can be taken to generate a wedge (emissions reductions that begin promptly and grow to a billion tons of carbon or 3.7 billion tons of CO_2 emissions in 2054). They note that on a global basis seven of the fifteen wedges will be required to achieve a leveling off of emissions at 2004 levels in 2054.[220] After five years, a single stabilization

216. *See* discussion *supra* notes 79 to 114 (idling), 202 (discussing trends in aggressive driving), 146 to 194 (indoor temperatures), and 115 to 143 (discussing trends in standby power use).

217. SCHIPPER, *supra* note 22, at 4 tbl.1.

218. Calculations are derived from EPA, UNIT CONVERSIONS, *supra* note 23.

219. *See* Pacala & Socolow, *supra* note 24, at 968–70.

220. Although Pacala and Socolow provide for stabilization at 2004 levels in 2054, *see id.* at 968, rather than leveling off in the near term with 60 to 80 percent reductions by 2050, the stabilization wedge concept can be adapted to account for the emerging consensus regarding the need

wedge would reduce CO_2 emissions by 370 million tons per year. The measures proposed here would generate roughly 150 million tons and thus would be equivalent to 40 percent of an emissions wedge in the short run.[221]

On the federal legislative level, the Lieberman-Warner Bill establishes a near-term target of limiting CO_2 emissions from regulated sources to 2005 levels by 2012.[222] Given projected business-as-usual increases, this seemingly modest requirement would require emission reductions of approximately 985 million tons of CO_2 in five years.[223] The low-hanging fruit described in this Article could be implemented quickly and could account for 15 percent of the total requirement. In comparison, the new Corporate Average Fuel Economy (CAFE) standards recently enacted in the Energy Independence & Security Act of 2007 are expected to produce annual reductions of roughly 210 million tons by 2020 and twice that by 2030.[224] The low-hanging fruit measures thus not only produce 75 percent of the 2020 reductions but do so far more quickly.

III. THE LOW-HANGING FRUIT IN CONTEXT

The existence of large, prompt emissions reductions that on plausible assumptions could be achieved at low cost raises an important question: Why is the individual and household sector not the focus of substantial interest by policymakers? One possible answer is that the reductions simply do not exist at the magnitudes or costs estimated above in Part II. Our analysis is a first, rough attempt to quantify the issue, and until a far more detailed analysis is conducted it will not be possible to make these claims with more certainty. We have made conservative assumptions at numerous stages in the analysis, however, and it is more likely that we have erred on the side of pessimism rather than optimism concerning the magnitude, speed, and cost of the emissions reductions. We examine in this Part the potential explanations for the lack of attention to individuals and households by policymakers and the academy.

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for a short-term target and a more aggressive long-term target than leveling off at 2004 levels in 2054. *See* James Hansen et al., *Dangerous Human-Made Interference With Climate: A GISS ModelE Study*, 7 ATMOSPHERIC CHEMISTRY & PHYSICS 2287, 2303–07 (2007).

221. *Id.*

222. *See* America's Climate Security Act of 2007, S. 2191, 110th Cong. § 1201 (2007) (providing 5.775 billion CO_2 equivalent allowances in 2012, the total emitted by the covered facilities in 2005).

223. This estimate is based on Energy Information Administration's projected 1.2 percent increase per year in U.S. CO_2 emissions. *See* ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2007 WITH PROJECTIONS TO 2030, at 13 (2007).

224. *See supra* note 26.

A. Policymakers

One possible reason for the lack of attention by policymakers is a lack of information about the magnitude of individual and household emissions and the reductions that can be achieved at low cost. This lack of awareness may begin at the conceptual level. For more than thirty years, environmental policymaking has focused largely on regulating large industrial sources, and this focus has created a misperception that industrial regulation is the best, if not the only way to address a wide range of environmental problems.[225] Given this framing, it is very difficult for policymakers to treat individual and household emissions with the same amount of rigor and effort as industrial emissions, even though the individual and household sector exceeds the industrial sector in CO_2 emissions in the United States.[226] As a result, government reports tend to understate the contributions of individuals and households; many agencies lack the expertise to address the sector; and at least since the energy crisis of the late 1970s, minimal research has been conducted to develop optimal policies for reducing emissions from the sector.[227]

This lack of awareness may extend from the conceptual to the applied level. The problem is not that information is unavailable. The seven measures highlighted above have not been discovered after many years of investigation. They are measures that are commonly listed among a host of activities that individuals and households can take to reduce energy consumption, reduce CO_2 emissions, and save money. These lists can be found at tens and perhaps hundreds of sites on the Internet.[228] These lists are an important signal of the types of actions that can be taken, but they are far too informal and ad hoc to assist policymakers. The lists' recommendations are often inconsistent and poorly documented.[229] The activities cited often include a mix of things people can do easily, with some difficulty, or with great difficulty. No systematic, rigorous effort has been made to assemble and evaluate the most promising emissions reductions opportunities from the individual and household sector.

Even those policymakers who understand the large emissions reductions potentially available from this sector may be skeptical about the prospects

225. *See* Vandenbergh, *supra* note 16, at 524–35.

226. *See* discussion *supra* note 38 and accompanying text.

227. *See* Vandenbergh & Steinemann, *supra* note 1, at 123 n.94 (quoting Paul Stern for the proposition that the recent interest in energy behavior research after a lull of more than two decades has been a "Rip Van Winkle experience").

228. *See, e.g.*, discussion *supra* notes 186–189.

229. *See, e.g.*, Padgett et al., *supra* note 70, at 66 (noting the comparative inconsistency and the lack of transparency of ten online carbon calculators).

of achieving such reductions. The success of information-based behavior change efforts has varied widely, and skepticism abounds. The National Research Council (NRC) has described many behavior change efforts as "notoriously ineffective."[230] Perhaps most importantly, the NRC has noted that although personal barriers to individual behavior change (for example, steep discount rates) are important, the barriers to policymakers are equally important. In particular, policymakers often fail to take advantage of the best social and behavioral science when designing and implementing policies directed at individuals and households.[231] Robert Cialdini has documented this reluctance in studies of information campaigns intended to reduce the stealing of petrified wood.[232] Although Cialdini was able to demonstrate that a new message was far preferable to the one being used by the National Park Service, the policymakers adopted the results from their own informal visitor surveys and did not change their approach to reflect the research results.[233]

Informational strategies that take advantage of the best social and behavioral science can be very effective, however.[234] In addition, policymakers need not use informational efforts alone. The optimal mix of policy measures will vary based on the type of behavior at issue and other factors. The important point is that many politically viable, low-cost interventions are available, including simple education campaigns, financial incentives, technology mandates imposed on manufacturers, and modest regulations directed at individuals.

An additional potential concern to policymakers is the out-of-pocket cost to government. Although the total national economic cost of the low-hanging fruit interventions may be available at less than half of the costs of efforts proposed or adopted at the federal, state, and local levels, what may matter most to policymakers is who bears those costs. Many of the costs of the proposed cap-and-trade system and other industrial measures will be borne not by government, but rather by the regulated community.[235] This

230. NRC, DECISION MAKING, *supra* note 14, at 74.

231. *Id.* at 74–78.

232. *See* Robert B. Cialdini et al., *Managing Social Norms for Persuasive Impact*, 1 SOC. INFLUENCE 3 (2006); *see also* Robert B. Cialdini, *Basic Social Influence Is Underestimated*, 16 PSYCHOL. INQUIRY 158, 159 (2005) (describing underestimation of the persuasive power of descriptive norms by policymakers).

233. Cialdini et al., *supra* note 232, at 12. Although legitimate concerns exist about government use of propaganda, the kinds of informational measures discussed in this Article all include only the use of accurate information to stimulate behavior change, not the use of inaccurate or incomplete information.

234. *See* discussion *supra* notes 73–78.

235. *See* discussion *supra* notes 6–7.

cost-shifting helps to obscure the total cost from the public and to shift those costs to industry, at least at the outset.

In contrast, government typically bears the costs of public information campaigns and subsidies. The magnitude of the costs thus may be more transparent to the public. In addition, the public may bear the costs directly in the form of higher taxes rather than indirectly through the increased cost of goods, passed along by regulated industries. As a result, the savings (for example, from reduced energy use) may be less obvious to the public than the potential tax increases to pay for information campaigns and subsidies. Although the issue of government-borne cost is important, the ultimate savings to individuals and households are large, as are the net social benefits, suggesting that out-of-pocket government costs should not pose an insurmountable barrier.

B. Academicians

For the academy, efforts to reduce emissions from individual and household behavior present difficult challenges at the intersection of theory and practice. In theory, price increases, whether driven by a carbon tax or a cap-and-trade program, should drive consumer behavior in desired directions. If individuals respond robustly to price, then theoreticians can model behavior with relative ease and can focus on setting the right price for carbon-emitting behaviors. This theoretical approach is appealing in that it allows the academy to give policymakers simple, understandable answers when asked how to reduce emissions efficiently.[236] Under this approach, if carbon taxes are politically radioactive, the second-best solution of reducing individual and household emissions via the price increases that would follow from a cap-and-trade program seems appealing.[237]

Yet numerous empirical studies demonstrate that in practice, limited information, high transaction costs, and a wide range of behavioral phenomena limit the extent to which price alone affects behavior.[238] In response, the social sciences offer policymakers a veritable Tower of Babel. People act

236. *See, e.g.*, *Approaches to Reducing Carbon Dioxide Emissions: Hearing Before the H. Comm. on the Budget*, 110th Cong. 4–5 (2007) (statement of Peter Orszag, Director, Congressional Budget Office), *available at* http://www.cbo.gov/doc.cfm?index=8769&type=1; *see also* Orszag, *supra* note 48.

237. *See* Robert N. Stavins, *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?*, 1997 U. CHI. LEGAL F. 293, 293–329; Ian W.H. Parry, & Roberton C. Williams III, *A Second-Best Evaluation of Eight Policy Instruments to Reduce Carbon Emissions*, 21 RESOURCE & ENERGY ECON. 347, 347–73 (1999).

238. *See generally* NRC, HUMAN DIMENSION, *supra* note 13, at 55–105 (citing studies).

rationally.[239] But not always.[240] Framing information matters.[241] But which frame matters most may be very context- and person-specific.[242] The focus of policies should be on the individual,[243] the group,[244] or some combination of smaller and larger groups.[245] Social marketing works.[246] Except when it does not.[247] In the face of these conflicting messages, even if policymakers are inclined to tackle individual and household emissions directly, it is not surprising that they rarely do so.

Does this analysis suggest that the low-hanging fruit are not so low-hanging after all? We think not. The seven actions identified in this Article can be addressed promptly using existing knowledge and can yield prompt, large, low-cost emissions reductions. To take full advantage of the emissions reductions available from the individual and household sector over the long-term, however, the academy will need to mobilize in ways that are all too rare.[248] In particular, academicians will need to make sufficient sense out of the multitude of behavioral theories and empirical studies to provide policymakers with sound policy advice. In some cases, the attempt to do so

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239. Vernon L. Smith, *Rational Choice: The Contrast Between Economics and Psychology*, 99 J. POL. ECON. 877 (1991).

240. *See* Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263 (1979); Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471 (1998).

241. *See, e.g.*, PAUL SLOVIC, THE PERCEPTION OF RISK 70–71 (2000) (noting that if a risk is stated as a lifetime cumulative risk, it may be more likely to provoke behavior change than if stated on a per-occurrence basis); *see also* Marilyn B. Brewer & Roderick M. Kramer, *Choice Behavior in Social Dilemmas: Effects of Social Identity, Group Size, and Decision Framing*, 50 J. PERSONALITY & SOC. PSYCHOL. 543 (1986); Daniel Kahneman & Amos Tversky, *Choices, Values and Frames*, 39 AM. PSYCHOLOGIST 341 (1984); Christopher McCusker & Peter J. Carnevale, *Framing in Resource Dilemmas: Loss Aversion and the Moderating Effect of Sanctions*, 61 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 190 (1995).

242. *See* Margaret A. Brunton, *One Message for All? Framing Public Health Messages to Recognize Diversity*, 31 INT'L J. INTERCULTURAL REL. 127 (2007); Peter Salovey & Pamela Williams-Piehota, *Field Experiments in Social Psychology: Message Framing and the Promotion of Health Protective Behaviors*, 47 AM. BEHAV. SCIENTIST 488 (2004).

243. *See, e.g.*, Charlie Wilson & Hadi Dowlatabadi, *Models of Decision Making and Residential Energy Use*, 32 ANN. REV. ENVTL. RESOURCES 169 (2007) (noting that differing perspectives of the social and behavioral sciences lead to different recommended policy interventions). Examples of fields that focus on the individual include economics and cognitive psychology.

244. An example of a field that focuses on the group is community psychology.

245. Examples of fields that focus on social interactions include social psychology and sociology.

246. Xinying Sun et al., *Social Marketing Improved the Consumption of Iron-Fortified Soy Sauce Among Women in China*, 39 J. NUTRITION EDUC. & BEHAV. 302 (2007); A.M. Olshefsky, M.M. Zive, R. Socolari & M. Zuniga, *Promoting HIV Risk Awareness and Testing in Latinos Living on the U.S.-Mexico Border: The Tu No Me Conoces Social Marketing Campaign*, 19 AIDS EDUC. & PREVENTION 422 (2007).

247. Doug McKenzie-Mohr, *Social Marketing for Sustainability: The Case of Residential Energy Conservation*, 26 FUTURES 224 (1994).

248. *See* Claudia H. Deutsch, *A Threat So Big, Academics Try Collaboration: Disciplines Cross Lines to Fight Global Warming*, N.Y. TIMES, Dec. 25, 2007, at C1.

will reveal the need for theoretical and empirical studies to fill substantial research gaps.[249] In others, it will require reconciling the results of the complex mix of existing theoretical and empirical studies into a coherent, accessible set of policy recommendations and convincing policymakers to rely on the best social science, rather than on intuitions that are often flawed.

This work will be a challenge. It will require social psychologists and sociologists to engage productively with scholars in other social science disciplines as well as scholars in law, policy, and business. It will require scholars from many fields to focus their research on questions that may not be within their comfort zone or that may not be of the most intrinsic interest. It also will require that other scholars learn what economists have known for decades: To influence policy, research has to generate concrete, simple, empirically supported, actionable recommendations.

We see the early signs of a mobilization of academicians and policymakers to address this problem. A recent conference brought together many leaders from the academic and policy realms to discuss behavior and climate change.[250] We have formed a research network of environmental engineers and scientists, social and behavioral scientists, and law and policy experts to identify and to engage the most important questions about individual and household emissions.[251] Other initiatives, centers, and institutes around the United States and the globe are working on various aspects of individual environmentally significant behavior.[252] These early efforts are just beginning to conduct basic and applied research and to communicate the results necessary to enable policymakers to address the individual and household sector. If the research focuses on the most pressing questions and the results are communicated successfully to policymakers, we are confident that the low-hanging fruit we have identified here will only be the first of many actions to reduce individual and household emissions.

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249. For a recent identification of research gaps, see NRC, DECISION MAKING, *supra* note 14, at 69–84.

250. *See* Behavior, Energy & Climate Change Conference, Nov. 7–9, 2007, http://www.aceee.org/conf/07becc/07beccindex.htm (Co-hosted by the American Council for an Energy Efficient Economy, the Stanford University Precourt Institute for Energy Efficiency, and the University of California Institute for Energy and Environment.).

251. *See* Vanderbilt University, Climate Change Research Network, http://law.vanderbilt.edu/academics/academic-programs/environmental-law/climate-change-network/index.aspx (last visited July 14, 2008).

252. *See* NRC, HUMAN DIMENSIONS, *supra* note 13; Columbia University, Center for Research on Environmental Decisions, http://www.cred.columbia.edu (last visited July 14, 2008); Michigan State University Environmental Science & Policy, http://www.espp.msu.edu/about/index.html (last visited July 14, 2008); University of Colorado-Boulder, Cooperative Institute for Research in Environmental Sciences, Education Outreach Program, http://cires.colorado.edu/education/k12 (last visited July 14, 2008); University of Oxford, Environmental Change Institute, http://www.eci.ox.ac.uk (last visited July 14, 2008).

CONCLUSION

In sum, we believe that the low-hanging fruit strategy advocated in this Article has a reasonable chance of achieving the 7-in-5 target, whether through a single, massive public information campaign or a combination of measures. The effort also may help the general public recognize that it is a key component of both the problem and the solution to climate change. Once a sense of responsibility is fostered, individuals will increasingly seek out opportunities to confront this issue, whether through direct, consumer, or civic actions. Perhaps most importantly, this strategy may call attention to the need for policymakers and academicians to address the individual and household sector with the same vigor as other regulatory targets.

We are not advocating an exclusive focus on the individual and household sector. We believe that it is critical that calls for an individual and household response to climate change be simply one component of an integrated and comprehensive policy response directed at all major sources.[253] We also are not suggesting that informational efforts alone will achieve the targeted reductions. We expect that the optimal policy measures for addressing individual and household emissions will depend on the details of the behavior and its context in people's lives. For some actions, simple education campaigns may be most effective. For others, financial incentives may prove most efficient. For others where economies of scale apply, technology mandates may work best, such as for the adoption of automatic idle-stop devices to address personal motor vehicle idling.

The federal government appears to be only a few years away from forging a comprehensive emissions reduction program based on a cap-and-trade framework, and many states and local governments are far ahead of the federal government. Direct efforts to reduce emissions from individuals and households do not appear to be a typical focus, and yet the individual and household sector has much to contribute to reaching emission reduction goals. We see no reason for keeping individuals on the sidelines. An individual and household effort easily could be incorporated into federal, state, and local responses to climate change and may generate large reductions in less time and at lower cost than many of the other measures currently under consideration.

253. *Cf.* NEIL GUNNINGHAM, PETER GRABOSKY & DARREN SINCLAIR, SMART REGULATION: DESIGNING ENVIRONMENTAL POLICY 387–91 (1998) (asserting that the use of multiple complementary policy instruments often produces more effective and efficient policy outcomes than single policy measures alone).