# Climate Policy Outcomes in Germany

## *Environmental Performance and Environmental Damage in Eleven Policy Areas*[1]

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**Abstract**

Germany has reduced its emissions of greenhouse gases more than almost any other industrialized democracy and is exceeding its ambitious Kyoto commitment. Hence, it is commonly portrayed as a climate-policy success story, but the situation is actually much more complex. Generalizing Germany's per-capita emissions to all countries or its emissions reductions to all industrialized democracies would still very likely produce more than a two-degree rise in global temperature. Moreover, analyzing the German country-case into eleven subcases shows that it is a mixture of relative successes and failures. This analysis leads to three main conclusions. First, high relative performance and high environmental damage can coexist. Second, we should see national cases in a differentiated way and not only in terms of their aggregate performances. Third, researchers on climate policies should more often begin with outcomes, work backward to policies, and be prepared for some surprises. Ironically, the most effective government interventions may not be explicit climate policies, such as the economic transformation of eastern Germany. Moreover, the lack of policy-making in certain areas may undercut progress made elsewhere, including unregulated increases in car travel, road freight, and electricity consumption. Research on climate and environmental policies should focus on somewhat different areas of government intervention and ask different questions.

**Keywords**

climate policy; environmental policy; environmental outcomes; German unification; greenhouse gases; green parties; renewable energy; ecological tax reform.

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## Introduction

For good reason, Germany is seen as a leader in climate protection. Since the early 1990s, its ambitious reduction targets have been coupled with pioneering climate policies and strong advocacy for international climate agreements.[2] Moreover, Germany's greenhouse gas emissions fell by 23 percent from 1990 to 2010, which exceeded its Kyoto target of a 21 percent reduction. At the same time, the German case is much richer than the unalloyed success story that is it often portrayed to be. It is actually a mixture of successes and failures that require elucidation and analysis.

Doing so illustrates several problems with most scholarly work on environmental outcomes. The prevailing perspective conceives environmental outcomes in terms of environmental performance, in which countries are compared to each other in terms of the degree of progress. This article critiques that perspective and argues for the use of external criteria of environmental quality or damage, for a focus on failures along with successes, and for comparative analyses of differences in policy areas within countries.

This article addresses a persistent environmental problem, greenhouse gas emissions and climate change. Studies of environmental outcomes show that industrialized democracies have made much progress in some areas as they have become more affluent and technologically advanced (for example, $SO_2$ emissions or water pollution from sewage). But in other areas, serious problems have persisted and even accelerated (such as, threats to biodiversity, resource use, waste generation, soil contamination, and road transportation).[3] Anthropogenic climate change is a major problem of global scope, which has persisted and worsened since the first actions were taken to address it in the early 1990s. Germany is well suited for this analysis because it is one of the most successful industrialized democracies in addressing climate change. Examining a relatively successful case can help us understand how well the Western democracies are addressing persistent environmental problems.

In the next section, I assess the environmental performance approach and offer suggestions for improving it. Next, I briefly describe Germany's climate policies and then link the country's aggregate record of greenhouse gas emissions to global warming and climate change, in terms of the risk of a two-degree Celsius rise in global temperature under different scenarios. I then break down the German case into eleven subcases and compare the effectiveness of different government policies in them. The conclusions discuss the implications of this analysis for Ger-

man climate policies and for the study of climate policies and climate policy outcomes.

## The Environmental Performance Approach to Environmental Outcomes

Most scholarly work on environmental outcomes has proceeded on the basis of cross-national studies and has taken what can be called an environmental performance approach.[4] In this work, countries are ranked according to environmental indicators, cross-national variation is explained, or cases of successful environmental outcomes are identified and compared with each other. A related literature examines the relative strength of policies and the role of pioneers and leaders in the international diffusion of relatively strong policies.[5] In both literatures, there is a focus on relative performance, and on success rather than on failure.[6]

This work makes many important contributions. It places attention on the best results, which encourages others to strive toward them. It draws conclusions about trends and cross-national differences in outcomes, which serve as valuable reference points. Furthermore, it identifies a wide range of conditions that correlate with relative success and are likely to promote it. Some writers have focused on a combination of structural capacities together with the strategies and skills of actors in using them;[7] others on macro-level socioeconomic structures and political institutions;[8] and yet others on imitation by other countries and diffusion through international institutions.[9] These explanations of cross-national differences provide a framework for addressing questions about what could be done to achieve better outcomes.

Nevertheless, the environmental performance perspective also has several biases. First, the use of relative rankings rather than comparison to an external standard gives the approach a bias toward competition for its own sake. Relative standards can make a country look like it is doing well simply because others are doing worse. For example, Germany's per capita production of municipal waste was essentially unchanged from 1975 to 1995, yet this record placed it second best out of seventeen OECD countries, since fifteen of them had increases during that period.[10] In this framework, the implicit goal seems to be for a country to become, or remain, a leader rather than to solve environmental problems. Second, the environmental performance approach tends to obscure the continuing environmental harms and burdens that result from the practices of even

the leading countries, and hence draws attention away from the forces that limit or prevent improvements. There is a bias toward seeing success and ignoring failure, especially in relatively successful countries.

Third, the widespread use of a large-n cross-national method in this literature means that country cases almost always are treated in an undifferentiated way. In any given area, whether sewage treatment or $SO_2$ emissions, a country is seen as a success, a failure, or somewhere in between. It has a rank within a league table of comparable countries, serves as a data point in a statistical analysis, or provides an example of an outcome that is clearly more successful than the average. Again, for relatively successful cases, such as Germany in the climate policy area, this may create a bias toward complacency, because the case tends to be treated simply as a success, even though it contains aspects of both success and failure.[11]

In order to counterbalance these tendencies, I make several proposals. First, the reference points of analysis should include environmental burdens and damage for natural systems,[12] not only the performance of other countries, the goals set by a national government, the targets established in international agreements, or the rate of damage per unit of GDP or other measures of efficiency. We need to keep in mind the present rate of damage, recent trends in damage rates, their likely trajectories, and the cumulative total of environmental damage. In climate policy, as in many other environmental policy areas, the most reliable data on environmental damage consists of proximate indicators of environmental burdens, in this case greenhouse gas emissions.[13]

Second, if we keep one eye on environmental burdens, we are likely to see failure as well as success in environmental outcomes. In areas of persistent problems, even countries that are environmental leaders may still produce major environmental damage.[14] Such cases involve both success, in doing better than other countries and often in reducing damage rates, and also failure, in not reducing damage rates to what is sustainable for the natural systems on which human populations depend. Keeping both aspects in view produces a more realistic picture and leads to different foci and questions than does focusing on success alone.

Third, since failure and success can coexist, differentiated analysis of country cases is needed. A country's performance can be analyzed into subcases of relative success and relative failure, which can be defined by policy areas, economic sectors, regions, or time periods. In addition, even successful aspects may be less successful than they could have been, and some factors and trends may cancel out gains made elsewhere.

The approach indicated by these suggestions is meant to complement cross-national studies of environmental outcomes. As such, it can make several distinct contributions. Differentiated studies produce new variance to be explained, within a country rather than between countries. One kind of proximate explanation of the variance, undertaken in this article, involves comparing the effectiveness of different policies. In addition, deeper causes of policy outcomes can be sought and related to broad theories of environmental outcomes, although that is beyond the scope of this article.[15]

In addition, comparing the effectiveness of environmental policies and other government interventions is likely to raise new questions about policies. The most effective policies may not be those that have received the most attention in the environmental policy literature. In the case of some explicit, well-documented policies, the most important feature worth explaining may be their relative ineffectiveness. In other areas, the absence of policies may be the most salient feature calling for explanation.

## Climate Policies in Germany

Germany has been a leading country both in initiating domestic policies to limit greenhouse gas emissions and in pressing for international commitments. The following brief description is limited to the domestic side and to the policies that are most often identified as significant in scholarly writing on climate policies; these are policies of the federal government, notwithstanding the many initiatives by the Länder and local governments.[16] Early and relatively consistent target setting has been an important part of German climate policies. Following the report of a parliamentary Inquiry Commission formed in 1987, the federal cabinet and parliament in June 1990 approved a national goal of reducing energy-related $CO_2$ emissions by 25 percent over the 1987-2005 period.[17] Under the Kyoto Protocol, the European Union committed to a reduction of 8 percent in six major greenhouse gases (measured in $CO_2$ equivalent), and it ultimately assigned targets to its fifteen members in 1998. As its part of this "burden sharing," Germany accepted a target of a 21 percent reduction from 1990 to the 2008-2012 period. After 1998, the German government emphasized the latter, more modest goal of a 21 percent reduction by 2010 rather than its earlier goal of a 25 percent reduction by 2005. In its 2005 Climate Protection Program, however, the government set a new goal of reducing greenhouse gas emissions by 40 percent from 1990 to 2020, conditional on the EU countries committing to a 30 percent reduction over the same period.[18]

The federal government and parliament have pursued a number of major policies that were intended to help achieve these targets. First, they have strongly promoted renewable energy. The Electricity Feed-In Act, put into effect under a Christian Democratic-led government in 1991, required utilities to buy renewable electricity (including from wind, biomass, and hydroelectric power) at highly subsidized rates equaling 90 percent of retail prices. The growth of renewable energy was undercut somewhat in early 1998 by the liberalization of electricity markets, which led to price competition,[19] and by revisions to the Electricity Feed-In Act that limited payments for renewable electricity and capped its growth in some regions. Partly in response, the Renewable Energy Source Act was passed under the Social Democratic-Green government and took effect in April 2000 (with revisions in 2004). The new act guaranteed feed-in prices for renewable electricity for twenty years and distributed the costs of wind power subsidies among consumers served by all energy companies, rather than only those connected to the turbines. This act and later amendments also provided a tax exemption for biofuels beginning in 2002 and increased subsidies for biomass beginning in 2004. With the 2000 act, the German government set a target of doubling the share of electricity from renewable sources from 6.25 percent in 2000 to 12.5 percent in 2010.[20] The importance of expanding electricity generation from renewable sources was underscored by the government's 2001 agreement with the nuclear industry to phase out nuclear power, which led to plans to close all nuclear plants between 2003 and 2021.[21] Those plans were delayed by the new Merkel government after the 2009 Bundestag elections, but the government resumed the phaseout after the 2011 Fukushima nuclear disaster.

Second, in 1995 and 1996, the Kohl government reached voluntary agreements with industry to reduce $CO_2$ emissions. In exchange, the federal government agreed to forego energy taxes and a heat utilization ordinance for industry. Trade associations representing 80 percent of industrial production agreed to reduce specific $CO_2$ emissions (i.e., emissions per value added) by 20 percent from 1990 to 2005, but resisted targets for absolute emissions. The agreements were strengthened under the Schröder government in 2000, as industrial associations agreed to reduce specific $CO_2$ emissions by 28 percent over 1990-2005 and to cut specific greenhouse gas emissions by 35 percent by 2012. Moreover, the power industry agreed to further voluntary cuts, totaling an annual reduction of 45 million tons (megatons, Mt) in $CO_2$ emissions by 2010, of which 20 megatons were to come from through increased use of cogeneration, i.e., combined heat and power.[22]

Third, spurred in part by persistently high unemployment, the Red-Green parliamentary majority passed a revenue neutral ecological tax reform effective April 1999. This increased taxes on energy while reducing employers' social security contributions by about 0.8 percent; the dual aims were to promote employment and reduce carbon dioxide emissions. The tax reform provided for a gradual rise in taxes on gasoline, diesel fuel, heating oil, natural gas, and electricity over the 2000-2003 period. By far the highest rates were for gasoline and diesel fuel; coal was exempted, and manufacturing industry initially paid only 20 percent of the full rate. The ecological tax was later strengthened so that, effective in 2003, manufacturing industry, agriculture, and forestry were required to pay 60 percent rather than 20 percent of the full rate. In addition, laws passed in 2000 and 2002 gave feed-in subsidies and other protections to combined heat and power facilities in both manufacturing and the power generation industry; this sector had been undermined by EU-driven electricity deregulation in the late 1990s.[23]

Fourth, a variety of energy efficiency policies were passed in the 1990s and 2000s. Notably, a Buildings Energy Efficiency Ordinance took effect in 2002, requiring insulation and boiler improvements in older residential buildings, penalties for electric heating, measures intended to reduce energy consumption by one third in new buildings, and eventually energy efficiency certificates for new houses.[24] Finally, the German government enacted an emissions trading law in 2004, which implemented the EU's Emissions Trading System. The first round (2005-2007), however, was very lax, calling for fewer reductions than the voluntary agreements did. The Second National Allocation Plan (2008-2012) was initially rejected by the European Commission and then made somewhat stricter, providing for cuts of 20.9 megatons per year by the end of the period, which was 4.4 percent of 2005 emissions for the covered sectors.[25]

## Germany's Greenhouse Gas Emissions and Major Global Climate Change

### *Major Reductions in Emissions*

Largely as a result of these policies, Germany has significantly reduced its greenhouse gas emissions and is one of the two leaders in this area among the industrialized democracies, along with Britain. From 1990 to 2009, the last year for which cross-nationally comparable data are available, Germany's annual emissions declined from 1,248 megatons of $CO_2$-equivalent

to 920 megatons.[26] This was a reduction of 26.3 percent from the Kyoto baseline year, an impressive decline in international comparison that put Germany on target easily to meet its Kyoto target of a 21 percent reduction from 1990 to the 2008-2012 period. Even in 2008, before economic recession drove the emissions of Germany and other Western democracies sharply lower, Germany's emissions were 22 percent lower than in 1990. Among the industrialized democracies in 2009, only Britain's decline (27 percent) was close to Germany's,[27] although several others also reported relatively large reductions (Sweden at 17 percent, Belgium 13 percent, Denmark 10 percent, and France 8 percent). While many East European "economies in transition" reported much larger decreases than Germany, ranging from 32 percent in the Czech Republic to 60 percent in Ukraine, their reductions were made possible by their wholesale transitions from extremely energy inefficient command economies to market economies.[28]

Germany's improvement stands out even more when compared with the large increases over this period in the U.S. (7 percent), Canada (17 percent), Australia (30 percent), and some rapidly developing European countries such as Ireland (14 percent), Portugal (26 percent), and Spain (30 percent). The worsening trend in the U.S., which increased emissions by 441 Mt/year in this period, exceeded the 328 Mt/year reduction in Germany.[29]

### *From Emissions to Climate Change*

Nevertheless, to balance the picture of progress and apparent success in Germany, it is necessary to look at how much harm still is being done by Germany's current rates of emissions. This requires linking global emissions to global temperature and climate change, and Germany's emissions to global emissions.

The effects of temperature change on climate change involve much uncertainty and experts make a range of projections.[30] Nonetheless, at present there is a very broad agreement among climate scientists that human-induced warming of greater than two degrees Celsius compared to pre-industrial temperatures would entail major, undesired changes to the climate system and temperature increases that would persist for centuries.[31] In their meta-analyses, the Intergovernmental Panel on Climate Change (IPCC) and the Stern Review project that two degrees of warming would increase the damage from floods, storms, and erosion, and would salinize freshwater and reduce water supplies for hundreds of millions of people. They estimate that such warming would also reduce tundra areas by one half and cool conifer forests by one quarter, put 30 percent of

species at risk of extinction, and reduce crop yields in tropical regions. It would change the distribution of some disease vectors and produce mass migration in some cases and overall negative effects on human health.[32]

Therefore, in the following I will take two degrees Celsius as the reference point when assessing the likelihood and timing of major anthropogenic climate change under different emissions scenarios. It is important, however, to bear in mind that the actual effects of a two-degree rise could be more or less severe, and that there is no clear threshold between "safe" and "dangerous" amounts of global temperature rise.[33]

What amount of greenhouse gas emissions is permissible without exceeding two degrees of warming? Since damage is cumulative and major damage would occur only as a result of years of continued emissions, a cumulative greenhouse gas budget approach is reasonable. Projecting the effects of emissions on global temperature also involves much uncertainty. Therefore, the following analysis is based on the results of the widely cited model by Malte Meinshausen and colleagues, which lies in the mid range of estimates of the sensitivity of climate to greenhouse gas concentrations in the atmosphere.[34] At the same time, it is worth noting that this model understates the long-term challenge of reducing emissions because it assumes extremely low emissions after 2049.[35] That means that if this model's estimates are biased, they are likely to be biased toward optimism about avoiding major climate change in the long term. The result of this model is that cumulative global anthropogenic emissions of the Kyoto greenhouse gases would need to be limited to about 1500 billion tons (gigatons, Gt) in $CO_2$ equivalent during the period from 2000 to 2049. Doing so would hold the risk of major climate change (two degrees of warming) to 25 percent.[36] Since an estimated 551 gigatons were emitted worldwide from 2000 to 2010,[37] including land-use changes, this leaves a remaining budget of only 949 gigatons for the period from 2011 through 2049.

Hence, the question is how do Germany's emissions reductions contribute to the world staying within, or exceeding, this budget? Of course, the answer depends on emissions trends in all countries, including the industrialized democracies, former communist countries, and developing countries.[38]

## Germany as a Model for the World?

First, I will assume equal per capita emissions for all countries in the world. In this scenario, Germany's per capita emissions, which were 11.4 tons/person-year in 2010, are far from being a good model.[39] Germans' emissions are lower than those for the industrialized democracies as a whole (14.5 tons per person-year in 2005), but much higher than the world average (6.0 tons per person-year in 2005).[40] If all countries emitted at Germany's per-capita rate from 2011 onward, we would exhaust the 1500-gigaton budget in 11 years, by the year 2021, and have a 25 percent risk of major climate change (see Table 1).[41] Of course, countries with higher per capita emissions of greenhouse gases, such as the U.S. (22.1 tons/person-year in 2010), are even poorer models for the rest of the world.[42] If all countries emitted at the U.S. rate, we would exhaust the 1500-gigaton budget in only six years, in 2016.[43]

How much would Germany need to reduce its emissions in order to serve as a model for the world? Assuming a 1500-gigaton budget for the years 2000-2049 and an average world population of 8 billion over that period, then the "fair share" of emissions in each country would be an estimated 3.04 tons/person-year.[44] Germany's current per capita emissions are about three and a half times as high as that. Therefore, Germany would need to reduce its per capita emissions by an additional 73 percent, below its 2010 levels, in order to reach its fair share, if the goal is to avoid two degrees of warming. If the goal is to prevent all warming, an even sharper estimated reduction of 86 percent in Germany's per capita $CO_2$ emissions would be needed.[45]

***Table 1:*** Germany's Contributions to Global Climate Change: Three Scenarios

| Scenario | Assumptions | Emission rates (Kyoto gases, in $CO_2$-equivalent) | Number of years after the year 2010 until we would exhaust the 1500-Gt $CO_2$eq budget (with a 25 percent chance of two degrees Celsius warming) | Number of years after the year 2010 until we would exhaust the 2000-Gt $CO_2$eq budget (with a 50 percent change of two degrees Celsius warming) |
|---|---|---|---|---|
| Global equal per-capita emissions, imitating Germany | All countries emit at Germany's 2010 per capita emissions rate | 11.4 tons/person worldwide | 11 years (exhausted in 2021) | 16 years (exhausted in 2026) |
| Global equal per-capita emissions, imitating U.S. | All countries emit at U.S.'s 2010 per capita emissions rate | 22.1 tons/person worldwide | 6 years (in 2016) | 9 years (in 2019) |
| Global inequality, with industrialized democracies imitating Germany's 1995-2010 trend starting in 1996 | Industrialized democracies declining 1.2622 percent/year from 1995 emissions; EITs stable at their rates in 2000; DCs' rates rising 108 percent over 2000-2049 | Industrialized democracies: falling from 11.8 to 6.3 Gt/yr.; EITs: stable at 4.05 Gt/yr.; DCs: rising from 23 to 48 Gt/yr. over 2000-2049 | 23 years (in 2033) | 32 years (in 2042) |

EITs =economies in transition; DCs =developing countries; Gt =gigatons
*Sources:* see notes in text.

## Germany as a Model for the Industrialized Democracies?

Second, I will assume continued unequal per-capita emissions, and ask whether Germany's recent emissions reductions are a good model for the industrialized democracies. What would happen if all of them had followed Germany's example and reduced their emissions as Germany has

done over the last two decades? To be more realistic, I take Germany's trend in declining emissions over the 1995-2010 period, thus factoring out the emissions reductions that were due to unification, a kind of phenomenon that other Western democracies are unlikely to be able to imitate and that Germany is unlikely to repeat. Germany reduced its emissions by 17.3 percent from 1995 to 2010, which is an average reduction of 1.26 percent per year, compounded.[46] What if all the industrialized democracies had reduced their emissions at that rate every year starting in 1996 and going forward indefinitely? By 2049, they would have reduced their emissions by slightly less than 50 percent when compared with 1990.

This contribution, however, would not have been enough to avert major climate change. In reaching this conclusion, I make two additional assumptions. First, emissions by the postcommunist countries would be stable at their levels in 2000, taking account of the restructuring after the collapse of their state-managed economies. Second, I assume a mid range scenario for business-as-usual emissions growth by the developing countries.[47] Under these assumptions, even with the industrialized democracies' emissions declining at 1.26 percent per year starting in 1996, the 1500-gigaton budget would be exhausted in twenty-three years, by 2033. After that date, we would be committed to a 25 percent risk of major climate change, and nine years later, in 2042, we would be committed to a 50 percent risk (see Table 1).[48]

Of course, trends in the developing countries depend on many factors that are difficult to predict, such as economic growth rates, energy efficiency trends, and climate policies. Hence, another approach is to make no assumptions about them and to ask how much the developing countries could emit by 2050 if the industrialized democracies had reduced their emissions at Germany's 1.26 percent annual rate of reduction beginning in 1996. Unfortunately, even this relatively sharp rate of reduction would not leave much of the emissions budget remaining for the developing countries to use. For the world to stay under the 1500-gigaton cap, developing countries could emit only an annual average of 17.2 Gt/year over the 2000-2049 period, which is 31 percent lower than their actual emissions of 24.9 Gt in 2005.[49] Any medium term decline in developing country emissions is, of course, extremely unrealistic. From 1990 to 2005, those emissions rose at about 2.4 percent a year, totaling a 43 percent increase.[50]

In short, Germany's per capita emissions are far from being a good model for the rest of the world, and even its rate of reduction so far is not a good model for the industrialized democracies. German emissions are still so high that even if all other Western countries had made progress

similar to Germany, they would lead to major damage to the climate system long before 2050, under any reasonable assumptions about developing countries' emissions.

## A Disaggregated View of the German Case

Germany's large aggregate reduction in emissions represents both success and failure. It is a success because the reduction was higher than in any other Western country, but it is also a failure because Germany's per capita emissions have not been adequate to avoid contributing to major damage to the climate system. This point of view represents a modification of the usual environmental performance perspective. It raises two distinct questions: Why has Germany reduced its emissions so much; and, why has it not reduced them more than it has? These questions will be addressed first by identifying subcases in terms of policy areas and economic sectors that vary in the degree of emissions reduction or increase. Disaggregating the German case shows that it is a mosaic of successes and failures.

This analysis relies on the best available estimates of climate policy outcomes in Germany. Mainly these are the German government's estimates of policy effects, as reported in its Fourth and Fifth National Communications to the United Nations Framework Convention on Climate Change (UNFCCC).[51] These estimates are based on studies by a consortium of research institutes under contract to the environment ministry: the Deutsches Institut für Wirtschaftsforschung, the Forschungszentrum Jülich, the Fraunhofer-Institut, and the Öko-Institut. Their studies estimate the annual emissions decreases that are due to a wide range of policy measures relative to business-as-usual scenarios, including continued economic growth in the absence of the government interventions. In addition, I have used other studies where available, to estimate the impact of German unification policies,[52] renewable energy,[53] waste regulations,[54] and the ecotax reform.[55] In order to move from analyses relative to business-as-usual to a picture of how Germany's absolute emissions reduction from 1990 to 2010 was achieved, I have used Hans-Joachim Ziesing's macroscale analysis.[56]

These estimates have several limitations. In particular, they are sensitive to the assumptions made about business-as-usual scenarios. Also, since the studies are largely retrospective, they may not fully capture the effects of policies adopted in the last few years, such as the many policies adopted in the 2007 climate policy package or the 2009 energy saving

ordinance. Nevertheless, these estimates have been used in other academic studies[57] and to my knowledge, no scholarly critiques of them have been published. While the estimates are unlikely to be precisely accurate, they are the best available means for systematically comparing government interventions and they are plausible given the magnitudes claimed in relation to the absolute changes in emissions. They are likely to be accurate enough for the purpose here, which is to identify relative successes and failures and to draw broad conclusions about the diversity of climate policy outcomes. In any case, the purpose here is not to recommend or criticize particular types of policies as such, since the policy outcomes discussed here depend to a large degree on the details of the policies in question, the implementation process, and the social, economic, and environmental contexts of Germany.

Table 2 includes the most important government policies that were designed to reduce emissions, as well as two other interventions that had significant effects although they were not conceived as climate policies (unification policies and waste regulations). This table shows a great variety in the impacts of interventions from 1990 to 2010.[58] First, Germany had two government interventions with very large effects: the economic transformation of eastern Germany following unification in 1990, and the promotion of renewable energy. These two interventions together represent 53 percent of the emissions reductions attributable to government interventions.[59] Second, the German government has had three moderate successes that have been underemphasized in the academic literature on climate policies: recycling laws together with waste regulations reducing methane; voluntary agreements with adipic acid producers reducing nitrous oxide; and residential building ordinances to improve energy efficiency.[60] Together, these reduced emissions by an estimated 110 megatons of $CO_2$ equivalent ($MtCO_2eq$/year), which is 29 percent of those attributable to government interventions.[61]

Third, three major climate policies were flawed and largely ineffective. Although they generated much publicity and have been much studied, the voluntary agreements with industry, the ecological tax reform, and emissions trading together produced only an estimated 27 Mt/year in reductions, which is 7 percent of the total due to government action.[62] Fourth, the growth in per capita income and population led to large increases in transportation, household heating, and electricity consumption, which together *increased* emissions by about 240 Mt/year.[63] Without these sources of increase, Germany's overall temperature-adjusted emissions would have fallen by 44 percent rather than 25 percent over the 1990-2010 period.[64]

***Table 2:*** Estimated Relative Contributions of Major Government Interventions to Germany's Reductions in Kyoto Greenhouse Gas Emissions, 1990-2010

| **Source of reduction or increase in emissions** | **Emissions reduced (-) or added (+) in megatons $CO_2$ eqivalent/year** | **Percent of total emissions reductions attributable to government action** |
|---|---|---|
| Eastern German economic transformation policies* | – 112.9 | 29 percent |
| Renewable energy policies | – 95.3 | 24 percent |
| Waste regulations and biomass ordinance regarding methane; recycling laws and regulations | – 58.4 | 15 percent |
| Voluntary agreement between government and adipic acid producers regarding $N_2O$ | – 26.0 | 7 percent |
| Building ordinances | – 25.8 | 7 percent |
| Ecological tax reform | – 18.2 | 5 percent |
| Voluntary agreements between government and industry regarding $CO_2$ and other greenhouse gases | – 8.2 | 2 percent |
| Emissions trading system | – 0.4 | 0 percent |
| Industrial and commercial ordinances on heating and energy saving | – 11.0 | 3 percent |
| Combined heat and power (cogeneration) policies, including industrial cogeneration | – 5.5 | 1 percent |
| Transportation policies (fuel tax, rail regionalization, emissions-based road tax, high-sulphur fuel tax, cycling promotion, climate protection campaign, 130g $CO_2$ standard for cars) | – 16.0 | 4 percent |
| Agricultural policies on biogas, biomass, and organic farming (mainly regarding methane and $N_2O$) | – 5.8 | 1 percent |
| Coal mining: policy-induced production decline and methane regulations (regarding methane) | – 8.8 | 2 percent |
| **Subtotal: all reductions attributed to government actions** | **– 392.3** | **100 percent** |
| Reductions not driven by policies, including $CO_2$ reductions due to increased energy efficiency and reduced carbon content of fuel mix | – 189.1 | |
| **Subtotal: all reductions (gross)** | **– 581.4** | |
| Increases due to growth in income per capita** | + 214.6 | |
| Increases due to growth in population** | + 25.7 | |
| **Total net reductions 1990-2010** | **– 341.1** | |

* through 2000 ** energy-related $CO_2$ emissions; all other items are for the Kyoto gases estimated through 2010.
*Sources:* see the text and the accompanying notes.

The next section takes a closer look at these eleven subcases of relative success and failure. It compares the effectiveness of a number of policies, both explicit climate policies and others.

## Comparing the Outcomes of Policies

### *Effective Government Interventions*

In terms of reducing greenhouse gas emissions, the most effective government interventions have involved the privatization and restructuring of the East German economy in the course of unification. Although these were not the result of policies intended to protect the climate, they must be included in any understanding of how Germany has reduced its greenhouse gas emissions. These economic changes were the result of massive government interventions, including privatization by an agency of the federal government (the Treuhandanstalt); financial transfers from the west to east were over EURO 750 billion during the 1990-2000 period, including over EURO 160 billion for privatization and infrastructure upgrades.[65] A comprehensive study estimates that these interventions reduced emissions of $CO_2$ by about 105 Mt/year and of all greenhouse gases by about 113 Mt/year.[66]

Although unification, of course, depended on large forces outside the control of the West German government, the government did strongly shape the process of economic transformation and with it, the resulting emissions reductions. The transition to a market economy and the associated economic restructuring in the five new eastern Länder and East Berlin presented not only a great need for investment, but also great opportunities for reducing fuel use, increasing energy efficiency, and reducing carbon intensity. The 1990 currency reform sharply raised the relative costs of production in East Germany and triggered a collapse in industrial production, which fell by 60 percent in value from 1989 to 1991. Energy production was privatized, which led to increased efficiency, the shutting of many lignite plants in eastern Germany, and fuel switching, mostly to natural gas, which is only about half as carbon intensive as coal. Lignite fell from 69 percent to 38 percent of total primary energy consumption for electricity and heat production in eastern Germany from 1990 to 1995.[67]

In addition, energy price subsidies were ended and energy efficiency in buildings was greatly improved, as EURO 560 billion were invested in eastern German structures in the 1990s.[68] As a result, overall energy use in the

east fell 35 percent from 1990 to 1995.[69] Moreover, the reduction of livestock numbers and fertilizer use in the eastern states contributed to a decline in methane and nitrous oxide emissions in agriculture totaling about 10 $MtCO_2eq$/year.[70] Remarkably, by 2004, 86 percent of Germany's decline in energy-related $CO_2$ emissions had taken place in the eastern states, which had less than 30 percent of Germany's $CO_2$ emissions, 20 percent of its population, and 7 percent of its GDP at the time of unification.[71]

The second largest source of greenhouse gas reductions in Germany was the growth in energy production from renewable sources, mainly biomass and wind, but also energy from the Sun, waste, and hydroelectric facilities. As a result of the feed-in tariff policies described earlier, renewable energy grew rapidly. The share of total primary energy consumption from renewable sources rose from 1.9 percent in 1990 to 10.9 percent in 2010, and renewable source electricity rose to 17 percent of electricity consumption in the latter year.[72] From 1990 to 2009, increases in renewable energy in electricity, heat generation, and transportation resulted in an estimated 95 $MtCO_2eq$/year in emissions reductions.[73] About 81 percent of the avoided emissions were due to increased use of wind and biomass, with minor contributions from increased use of biofuels, solar energy, and hydroelectric power. Although the German government and scholars emphasize the growth of wind power,[74] data from the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) indicate that the increased use of biomass in this period prevented more emissions (49 Mt/year) than did wind power (27 Mt/year).

Third, several different policies, especially regarding methane and nitrous oxide, led to major decreases in emissions. A 1993 regulation limited organic waste from human settlements going to landfills and required recovery of landfill gas. Although the justification for the regulation made no mention of greenhouse gas emissions or climate change, together with a biogas ordinance in 2000, it reduced emissions by an estimated 30 Mt/year in 2010.[75] Together with energy savings due to the recycling law and regulations, policy measures in the waste sector reduced emissions by an estimated 58 $MtCO_2eq$/year in 2010.[76] In addition, the German government made a voluntary agreement with two producers of adipic acid, which began using thermal decomposition of nitrous oxide in 1997 and hence rapidly reduced their emissions of that greenhouse gas, by 26 $MtCO_2eq$/year.[77] Finally, the building ordinances adopted by the federal government in 1995 and 2002, together with a housing modernization program for the eastern states and a small $CO_2$ reduction program for residences in the western states, reduced emissions by an estimated 26 Mt/year.[78]

### Flawed and Relatively Ineffective Climate Policies

The ecological tax reform, described above, gets much attention in policy studies, but its effects on greenhouse gas emissions seem to have been modest, amounting to only an estimated 18 Mt/year in $CO_2$ emissions.[79] The relative ineffectiveness of the ecotax is due to several flaws. Its size is rather small, at EURO 16 billion or 0.7 percent of GDP in 2003. The ecotax helped raise Germany's total environmental taxes to only 2.5 percent of GDP in 2004, which placed the country only sixteenth out of thirty OECD countries.[80] Moreover, the tax suffers from qualitative defects. It is not based on the carbon content of the various fuels and it taxes different kinds of emitters very unequally. As initially introduced in 1999, the tax rate ranged from EURO 0 per ton of $CO_2$ emitted (for coal) to EURO 24 (for heating oil) to EURO 36 (electricity) to EURO 282 for unleaded gasoline.[81] While households and the transportation sector generally pay the full rate, existing electrical heating received a 50 percent discount and manufacturing an 80 percent discount, later reduced to 40 percent.[82]

Another flawed policy concerns the voluntary agreements between the German government and industry, also described above. All the voluntary agreements produced a total estimated reduction of only 8 Mt/year in emissions.[83] Although manufacturing industry experienced a large absolute decline in $CO_2$ emissions (58 Mt/year over the 1990-2008 period), over two thirds of the decline had occurred by 1995, largely due to the collapse of East German industry, and hence before the voluntary agreements had even been made. Therefore, the voluntary agreements represent mostly credit claiming by industry rather than a driver of investment planning.[84] Another problem is that the agreements were not legally binding; once they were voluntarily arrived at, compliance and reporting were also voluntary. Thus, although the German power industry agreed to reduce $CO_2$ emissions by 20 Mt/year through increases in cogeneration by 2005, instead its emissions increased by 30 Mt/year.[85] Moreover, industry made the agreements in order to avoid government policies that might have been more effective at reducing emissions. The 1995-1996 agreements were made in exchange for a government promise to not introduce an ecotax or a heat utilization ordinance, while the 2000 agreements were made to avoid an ordinance requiring industrial energy audits.[86]

Emissions trading also has been ineffectual so far in Germany. The German government enacted an emissions trading law in 2004, which implemented the EU's Emissions Trading System. However, as already noted, the first National Allocation Plan (2005-2007) was very lax. It provided for only 1.5 million tons/year in $CO_2$ reductions, which was less than what the

voluntary agreements with industry and the power sector had already called for.[87] The Second National Allocation Plan (2008-2012) was somewhat more stringent, calling for cuts of 20.9 megatons per year in the energy sector and energy-intensive industries from 2005 to 2012. Nevertheless, an external event, the 2008-2009 recession, intervened to drive emissions below the cap anyway. Hence, the German government estimates that emissions trading will produce only 0.4 Mt in annual reductions in $CO_2$ by 2010, and only 0.6 Mt by 2012.[88]

Finally, there were also other flawed policies or missed opportunities. In energy production, the EU-driven liberalization of electricity markets led to the modernization and fuller use of lignite power plants in eastern Germany and hence to a rise of 29 Mt/year in $CO_2$ emissions over the 1999-2003 period, more than half the 1990-1999 reduction in this sector.[89] Electricity deregulation also led to the shutdown of cogeneration plants in the late 1990s. Hence, heat produced by cogeneration plants, heating plants, and industrial heat fell by 19 percent from 1996 to 2000. This was a setback for climate policy since cogeneration saves about 20 percent of total energy compared with separate heat and power generation.[90] Moreover, hard coal subsidies continued at relatively high levels; although the federal subsidy was reduced from EURO 4.7 billion in 1998, it was still EURO 1.9 billion in 2008. As a result, energy consumed from hard coal declined more slowly than it would have in the absence of subsidies. It fell only 15 percent in absolute terms from 1990 to 2006, and by a total of 26 percent through 2010.[91]

### *Non-policies and Rising Consumption*

So far, I have described how government interventions reduced greenhouse gas emissions. But in key areas of the economy, the absence of government policymaking has permitted massive increases in emissions. In housing, electricity, and transportation, rising incomes and largely unregulated consumption and technological changes contributed to major increases in $CO_2$ emissions, totaling about 240 Mt/year.[92] These increases, however, were masked by large emissions declines due to efficiency improvements and fuel switching, including those driven by policy measures, in the same sectors.[93]

Therefore, emissions in the transportation sector present a very mixed picture. A major success was increased fuel efficiency, which led to an 18 percent reduction in $CO_2$ emissions per passenger kilometer for cars.[94] Since cars and motorcycles make up 80 percent of the total traffic volume, this was a major improvement. In particular, diesel motors became much

more efficient through high pressure fuel injection, and Germany became a large lead market for this technology. Passenger cars powered by diesel engines rose from 10 percent of the German new car market in 1990 to 42 percent in 2010.[95]

Yet, these efficiency gains were counterbalanced by other trends in passenger transportation. First, the 18 percent decline in specific $CO_2$ emissions could have been much larger if carmakers had not also made cars heavier and more powerful. New passenger cars registered in Germany became 41 percent more powerful, with virtually all the increase occurring after 1996; the share of four-wheel-drive vehicles also increased, from 3 percent to 11 percent of the total.[96] Moreover, the 18 percent efficiency increase was counterbalanced by a 27 percent increase in car travel.[97] Indeed, all forms of passenger travel increased, from about 10,900 to 14,000 kilometers per person-year. The less environmentally damaging forms of transportation, bus and rail travel, actually declined slightly as a share of all travel, a trend that is expected to continue.[98]

The trend toward physical growth has been even stronger in freight transportation, which grew by a massive 69 percent over the 1991-2009 period, much faster than the 27 percent growth in real GDP.[99] Efficiency improvements were significant, with $CO_2$ emissions per ton-kilometer falling by 40 percent, but they lagged far behind the increase in freight volume.[100] About half of the increase in freight transportation was due to the liberalization of transportation within the EU and the increase in trade with Eastern Europe.[101] In 2009, there was the equivalent of a ton of goods travelling 5000 kilometers for each German resident every year. Since road freight rose much more sharply than the use of barges and railways, those less environmentally damaging forms of freight transport fell from 35 percent to 27 percent of the total, while road freight's share rose to 70 percent through 2005.[102] Even after the introduction of kilometer-based charges for heavy trucks on the freeways in 2005, the volume of freight transported on the roads continued to rise, by 17 percent over the next three years,[103] before falling with the recession in 2009.

As a result of increased car and truck travel, there has been only a very small net decline in $CO_2$ emissions due to road transportation, about 5 Mt/year, which is 3 percent of the 1990 baseline.[104] Emissions reductions could have been much larger if it were not for the increases in car driving, vehicle weight and power, and freight transportation by truck.

In households, too, increased consumption due to lifestyle changes counteracted emissions reductions due to government policies. Policies to increase energy efficiency and reduce coal use for home heating helped

reduce households' $CO_2$ emissions by about 28 Mt/year, or 21 percent, from 1990 to 2010.[105] But those improvements would have been much larger were it not for contrary trends in consumption. Households became smaller (fewer persons per household) and residential units larger as people moved from rented apartments to houses, especially in eastern Germany.[106] Hence, living space per person rose by 20 percent, and residential fuel use (oil, gas, and coal) rose 3 percent despite the increased efficiencies.[107]

Finally, unregulated technological change drove a 13 percent increase in total electricity consumption through 2010. This was possible because Germany lacks a comprehensive electricity conservation policy.[108] Consumption rose across all sectors due to the development and dissemination of new electrical products, both producer and consumer goods. Households increased their electricity consumption by 20 percent, largely due to the increased use of air conditioning, other electrical appliances, cell phones, other rechargeable devices, and other devices that use energy in standby mode. Similarly, the rise of information technology in offices, commerce, and industry helped lead to a 20 percent increase in electricity consumption in the service sector and a 5 percent increase in manufacturing and mining. As a result, despite fuel switching from coal to renewables and natural gas and roughly stable nuclear power production, factors that should have produced large reductions in $CO_2$ emissions, total emissions from the power generation sector were basically flat from 1995 to 2008, declining by only 4 percent.[109]

## Conclusions

### *Summary of the Findings*

I have argued for certain revisions to the environmental performance approach to environmental outcomes. It is important to use natural systems as reference points and be open to seeing both successes and failures, which is best done through sufficiently detailed case studies of countries. In its present form, the environmental performance perspective is inadequate, because it downplays environmental damage and unsustainability. Hence, it fails to see the failures that are mixed in with successes and that indicate substantial room for improvement, even in the top performers.

Applying these suggestions in this article leads to several conclusions about the German case and more generally about the study of climate policies and outcomes (as well as other environmental outcome areas) in industrialized democracies. First, high performance and high environmen-

tal damage can coexist, and hence a fuller and more realistic understanding of outcomes requires keeping both aspects in view. In climate policy, even a Western democracy with one of the strongest performances since 1990 is contributing to a projected temperature rise beyond two degrees Celsius and hence to major environmental damage. This critique applies just as well to the other relatively successful countries, such as Britain, Sweden, France, Belgium, and the Netherlands, all of which have reduced emissions since 1990 and some of which have lower per capita emissions than Germany.[110]

Second, we should see national cases in a differentiated way and not only in terms of their aggregate performances. Leading countries are really mixes of successes and failures. Germany achieved notable reductions in some areas, through the economic structuring of the eastern states, promotion of renewable energy, regulation of methane in the waste sector, agreements regarding nitrous oxide in adipic acid production, and building efficiency ordinances. Other policies were much less effective, including the voluntary agreements with industry, the ecological tax reform, and emissions trading. The same general point also applies to laggards such as the U.S., which has had improvements in energy efficiency through federal appliance standards and strong recent growth in wind power, alongside other areas of significant climate policy failure, such as an increase in coal-generated electricity.[111] Differentiated studies of country cases can help correct the tendency to over-simplification found in large-n studies of environmental outcomes. Dividing a country into subcases based on policies, economic sectors, time periods, or regions also creates more variance to explain, and can aid in the development and testing of theories of environmental outcomes.

Third, increased consumption in areas without strong policies can undo many of the gains made in other areas of government intervention. Germany had significant sources of emissions increase, in the growth of passenger and freight transportation, residential living space, and electricity consumption. These trends are found in most Western countries, including those with overall emissions reductions. Passenger transportation increased in twenty-one out of twenty-two rich OECD countries, and freight transportation increased in nineteen of them over the 1990-2004 period. In Britain, the other leading industrialized democracy in emissions reductions, passenger car travel nonetheless rose 18 percent, road freight by 38 percent, and electricity consumption by 15 percent from 1990 to 2006.[112]

Fourth, research on climate policies should begin with outcomes, and then ask somewhat different questions about policies than it has so far. The

areas of greatest effectiveness in reducing emissions in Germany contrast greatly with the climate policies that policy researchers have identified as most important. The policy literature has focused on six policy areas, which generally are also those that received the most political attention: emissions target setting; renewable energy; voluntary agreements with industry; the ecological tax reform; energy efficiency measures in buildings; and emissions trading.[113] But three of these major climate policies, i.e., the ecotax, voluntary agreements, and emissions trading, have not led to major reductions so far. This does not mean that these types of policies are inherently ineffective in Germany or other countries. But we need to focus more on the policy details, implementation methods, and contextual factors that were responsible for their relative ineffectiveness in Germany.

At the same time, other policies have been more effective but have received less attention in environmental policy studies, partly because they were not adopted explicitly to protect the climate, i.e., the economic transformation of eastern Germany and the waste regulations. Another example is the liberalization of energy markets in Britain, which led to fuel switching that is estimated to have produced about half of that country's impressive emissions reductions through 2000.[114] Finally, in some areas, such as the growth in transportation and electricity consumption, the absence of major policies is responsible for increased emissions, and explaining that absence deserves much more study.

In short, it is sometimes helpful to think backwards from environmental outcomes rather than starting with policies, because policies vary greatly in effectiveness and emissions can also depend on factors besides explicitly designed climate policies. Doing so would raise questions that so far have received very little attention. For example, why did Germany shut down eastern German power plants after unification? Why were the ordinances regarding methane in the waste sector adopted and implemented so effectively? Why was the ecotax adopted in such a weak form? Why were policies on conserving electricity, curbing suburbanization in the eastern states, expanding public transportation, or limiting the huge increases in road transportation not even seriously considered, let alone adopted?

### *Party Politics as a Possible Explanation*

A systematic causal explanation of the relative successes and failures of climate policies in Germany is beyond the scope of this article, and is undertaken elsewhere.[115] But I would like to discuss one theoretical theme here, which has already cropped up in the policy narratives above, namely

the effects of political parties. Were some governing parties more successful than others in adopting policies that actually reduced emissions?

The large-n studies of environmental outcomes reach two main conclusions about parties. First, strong social democratic parties in opposition tend to increase environmental performance, but when in government their results are no better and in some cases worse than those of other parties. Second, the parliamentary strength of green parties is clearly and positively associated with environmental performance.[116]

How do the German cases analyzed above bear on those findings? At first glance, the CDU-led governments (1982-1998, 2005-present) seem to have been more effective than the SPD-Green governments (1998-2005). Unification, the first renewable energy law, the waste and recycling ordinances, and the voluntary agreement with adipic acid producers concerning nitrous oxide were all highly effective interventions that were adopted under Chancellor Helmut Kohl, while a main initiative of the Red-Green government, the ecotax, had relatively little impact. The contrast is not really that stark, since both types of governments had mixed records. The ineffectual voluntary agreements with industry concerning $CO_2$ were a cornerstone of Kohl's climate policy, and both the Schröder and Merkel governments pressed for overly generous quotas for German industry in the Emissions Trading System.

Moreover, the Red-Green government also had some successes, in the 2002 buildings ordinance and especially the strengthening of the renewable-energy law, which helped renewable energy production to take off in the 2000s. Along with unification, renewable energy promotion was one of the two most successful government interventions in the entire period. Even though the feed-in tariff policy began in 1990, it is unclear if much credit should be given to CDU-led governments for this success, since the entire initiative for the policy in 1990 came from parliament (first from a CDU and a Green deputy), it was initially resisted by the CDU-FDP cabinet, and the government very nearly succeeded in reducing feed-in tariffs in 1997. That attempt failed only because public protests from unions, trade associations, and religious groups led some CDU parliamentary deputies to join the Greens and SPD in opposing the measure.[117]

Nonetheless, CDU-led governments on the whole had more success than did the SPD-Green government. Yet this was probably due more to accidents of timing than to ideologically rooted differences between the CDU and SPD or their interest group ties. Both unification and the international emergence of the global warming issue occurred in the 1989-1992 period, while Kohl was chancellor, leading his government to pick the low-hang-

ing fruit among potential climate policies and leaving only costlier measures such as the ecotax or raising feed-in tariffs for the later SPD-Green government to attempt.

Moreover, party competition was a key driver of the climate policies of both kinds of government, and the environmental movement and the Greens were the crucial actors in that process, with the SPD often joining later and more ambivalently. This process began in the 1980s, when the CDU took action to restrict $SO_x$ emissions and the SPD gave up support for nuclear energy; the major parties were seeking to gain credibility on environmental issues after losing it through their opposition to environmental campaigns in the previous decade.[118] Since the Greens affected both major parties, the main differences in their records were due to accidents of timing. Since the CDU led the government for the first fifteen years after the Greens entered the Bundestag, the CDU had more opportunities to enact environmental policies than did the SPD.

Overall, the German cases support the findings of the large-n studies concerning party impacts. Party competition matters much more than who is in government, and green parties matter much more than do social democratic, Christian democratic, or other types of parties. Moreover, an examination of case studies within a country helps to flesh out the mechanisms behind the correlations discovered in the large-n studies. The effects of the major parties in government depended largely on competitive pressure from the environmental movement and the Greens.

### *Looking Forward*

The practical implications of this article may seem grim. Yet there are some hopeful signs in Germany recently. Solar power took off strongly after 2009 and already generates about half as much as wind power does. Its surge is helping to keep renewable energy growing at a rapid pace, doubling every seven years.[119] Residential and commercial buildings cut their $CO_2$ emissions from heating by about 25 percent over the last ten years, largely due to the increased use of biomass for home heating and the 2002 buildings energy efficiency ordinance.[120] As a result, Germany's overall emissions reductions accelerated slightly in the six years since 2005, with emissions dropping at a 1.3 percent annual rate after declining only 1.0 percent a year in the previous ten years. In trying to meet their ambitious reduction targets, German governments will be able to draw on two decades of experience with effective and ineffective policies.

In any case, my point is not that action to limit climate change is hopeless since even the leaders' efforts have been clearly inadequate. Rather,

the analysis shows that Germany, the other top performers, and all industrialized democracies need to work more effectively at making deeper emissions reductions more quickly. Even if we are unlikely to prevent two degrees of warming, it is still worth preventing even greater degrees of warming and the climatic consequences they would bring. This article has identified many failures in Germany, but each of these is also an opportunity for future emissions reductions, for example, through fuel switching from lignite and hard coal to renewables and natural gas, more support for cogeneration, a larger and carbon-based ecotax, stricter car fuel efficiency standards, higher road freight charges to fund investment in railroads, and lower emissions-trading caps. And of course, imitating the performance of countries such as the U.S., Canada, and Australia would bring us past two degrees of warming even faster and would commit the planet to even higher total amounts of warming and environmental damage than would following Germany's example.

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## Notes

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3. Martin Jänicke, Harald Mönch, and Manfred Binder, "Umweltindikatorenprofile im Industrieländervergleich: Wohlstandsniveau und Problemdruck," in *Umweltpolitik der Industrieländer: Entwicklung – Bilanz – Erfolgsbedingungen*, ed., Martin Jänicke (Berlin, 1996), 113-131, here 129-130; Lyle Scruggs, *Sustaining Abundance: Environmental Performance in Industrial Democracies* (New York, 2003), 30, 38, 43; Kirsten Jörgensen, "Ökologisch nachhaltige Entwicklung im föderativen Staat," FFU Report 04-2002, Environmental Policy Research Center, Free University of Berlin (2002) 8-9; Martin Jänicke, *Megatrend Umweltinnovation* (Munich, 2008), 172-175.
4. See, for example, Martin Jänicke, "Conditions for Environmental Policy Success," *The Environmentalist*, 12 (1992): 47-58; Markus Crepaz, "Explaining National Variations of Air Pollution Levels," *Environmental Politics*, 4 (1995): 391-414; Helmut Weidner, "25 Years of Modern Environmental Policy in Germany: Treading a Well-Worn Path to the Top of the International Field," Working Paper FS II 95-301, Social Science Center Berlin (1995), 46-51; Martin Jänicke and Helmut Weidner, *Successful Environmental Policy* (Berlin, 1995); Martin Jänicke and Helmut Weidner, *National Environmental Policies: A Comparative Study of Capacity Building* (Berlin, 1997); Detlef Jahn, "Environmental Performance and Policy Regimes: Explaining Performance in 18 OECD Countries," *Policy Sciences*, 31 (1998): 107-131; Lyle Scruggs, "Institutions and Environmental Performance in Seventeen Western Democracies," *British Journal of Political Science,* 29 (1999): 1-31; Scruggs (see note 3); John Dryzek, et al., "Environmental Transformation of the State," *Political Studies*, 50 (2002): 659-682; Andreas Duit, et al., "Saving the Woodpeckers," *Journal of Environment and Development*, 18 (2009): 42-61; Detlef Jahn, "The Politics of Climate Change," Paper prepared for the ECPR Joint Sessions of Workshops, 11-16 April 2008, Rennes, France.
5. See Mikael Andersen and Duncan Liefferink, eds., *European Environmental Policy: The Pioneers* (New York, 1997); Martin Jänicke and Klaus Jacob, *Environmental Governance in Global Perspective* (Berlin, 2007); Katharina Holzinger and Thomas Sommerer, "'Race to the Bottom' or 'Race to Brussels'? Environmental Competition in Europe," Working Paper 01/2008, Chair of International Relations and Conflict Management, University of Konstanz, 2008.
6. An exception is Tanya Börzel, *Environmental Leaders and Laggards in Europe* (Burlington, 2003), which examines laggard cases within Germany.
7. Jänicke and Weidner, *Successful Environmental Policy* (see note 4); Jänicke and Weidner, *National Environmental Policies* (see note 4); Martin Jänicke, ed., *Umweltpolitik der Industrieländer: Entwicklung – Bilanz – Erfolgsbedingungen* (Berlin, 1996).
8. Jänicke (see note 4); Crepaz (see note 4); Scruggs (see note 3); Jahn, "Environmental Performance" (see note 4); Detlef Jahn and Kati Kuitto, "Environmental Pollution and Economic Performance in the Baltic Sea Region," in *Governing a Common Sea,* Marko Joas, Detlef Jahn, and Kristine Kern, eds. (Sterling., 2008), 19-42; Christian Ricken, *Determinanten der Effektivität der Umweltpolitik* (New York, 1997); Jessica Pape, "Domestic Driving Factors of Environmental Performance," doctoral dissertation, Department of Political and Administrative Sciences, University of Konstanz, 2009.
9. Martin Jänicke, "Ecological Modernization: Innovation and Diffusion of Policy and Technology," FFU Report 00-08, Environmental Policy Research Center, Free University of Berlin, 2000; Jänicke (see note 3); Kerstin Tews, Per-Olof Busch, and Helge Jörgens, "The Diffusion of New Environmental Policy Instruments," *European Journal of Political Research*, 42 (2003): 569-600; Per-Olof Busch, Helge Jörgens, and Kerstin Tews, "The Global Diffusion of Regulatory Instruments," *Annals of the American Academy of Political and Social Sciences*, 598 (2005): 146-167; Jänicke and Jacob (see note 5).
10. Scruggs (see note 3), 38, 51.
11. Work treating German climate policies as effective and successful include Weidner and Mez (see note 2), despite the subtitle; Jänicke (see note 2); Rie Watanabe and Lutz Mez, "The Development of Climate Change Policy in Germany," *International Review for Environmental Strategies*, 5 (2004): 109-26; Helmut Weidner, "Klimaschutzpolitik: Warum

ist Deutschland ein Vorreiter im internationalen Vergleich?" Working Paper SP IV 2008-303, Social Science Center Berlin, 2008; Hans-Jochen Ziesing, "$CO_2$-Emissionen in Deutschland im Jahr 2008 im Abschwung," *Energiewirtschaftliche Tagesfragen*, 59 (2009): 64-69. The opposite tendency can be found in: Axel Michaelowa, "Germany: A Pioneer on Earthen Feet?" *Climate Policy*, 3 (2003): 31-43; "German Climate Policy between Global Leadership and Muddling Through," in *Turning Down the Heat: The Politics of Climate Policy in Affluent Democracies*, eds., Hugh Compston and Ian Bailey (New York, 2008), 144-163. Work on Germany as an international leader includes: Schreurs (see note 2); Steinar Andresen and Shardul Agrawala, "Leaders, Pushers and Laggards in the Making of the Climate Regime," *Global Environmental Change,* 12 (2002): 41-51; Michael Hatch, "The Europeanization of German Climate Change Policy," paper prepared for the EUSA Tenth Biennial International Conference, Montreal, Canada, 17-19 May 2007.

12. See BUND/Miseror, eds., *Zukunftsfähiges Deutschland: Ein Beitrag zu einer global nachhaltigen Entwicklung* (Berlin, 1997); Lester Brown, et al., *State of the World* (New York, 2009).
13. Andreas Duit, "Understanding Environmental Performance of States," Quality of Government Working Paper 7, Göteborg University, 2005.
14. Martin Jänicke, "Superindustrialismus und Postindustrialismus," in *Wissen für die Umwelt*, eds., Martin Jänicke, Udo Simonis, and Gerd Weigmann (Berlin, 1985), 237-60; Jänicke (see note 3), 172-175.
15. I do this for the German cases analyzed here in Roger Karapin, "Explaining Success and Failure in Climate Policies: Developing Theory through German Case Studies," *Comparative Politics*, 45 (2012), forthcoming.
16. Besides the sources cited below, other descriptions of German climate policies include: Helmut Weidner and Burkard Eberlein, "Still Walking the Talk? German Climate Change Policy and Performance," in *Governing the Energy Challenge: Germany and Canada in Multi-Level Regional and Global Context*, eds., Burkhard Eberlein and Bruce Doern (Toronto, 2009), 314-343; Umweltbundesamt, *Data on the Environment: The State of the Environment in Germany*, 2005 edition (Dessau, 2005); Jänicke (see note 2). For international aspects, see: Schreurs (see note 2); Loren Cass, *The Failures of American and European Climate Policy* (Albany, 2006).
17. Hatch (see note 11), 10; Michaelowa (see note 11), 33; Guri Bang, "Sources of Influence in Climate Change Policymaking: A Comparative Analysis of Norway, Germany, and the United States," Dr. Polit. thesis submitted to the Department of Political Science, University of Oslo, June 2003, 103.
18. Constanze Haug and Andrew Jordan, "Burden Sharing: Distributing Burdens or Sharing Efforts?" in *Climate Change Policy in the European Union*, eds., Andrew Jordan, et al. (Cambridge, 2010), 83-102; Michaelowa (see note 11), 33; Umweltbundesamt (see note 16), 27-28.
19. Umweltbundesamt (see note 16), 40-41.
20. Volkmar Lauber and Lutz Mez, "Renewable Electricity Policy in Germany, 1974 to 2005," *Bulletin of Science, Technology and Society,* 26 (2006): 105-120, here 106-107; Watanabe and Mez (see note 11), 119; Hatch (see note 11), 16; Umweltbundesamt (see note 16), 38.
21. "Nach Obrigheim ist Biblis dran," *netzeitung*, 11 May 2005; available at www.netzeitung.de/politik/deutschland/338169.html, accessed 30 January 2012.
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23. Watanabe and Mez (see note 11), 119-122.

24. Joachim Schleich, et al., "Greenhouse Gas Reductions in Germany: Lucky Strike or Hard Work?" *Climate Policy*, 1 (2001): 363-80, here 373-374; Watanabe and Mez (see note 11), 120.
25. Umweltbundesamt (see note 16), 43-44; IHS [Information Handling Services], "EC Finalizes National Allocation Plans on Emissions Trading for 2008-2012," 26 October 2007; available at http://engineers.ihs.com/news/eu-en-natl-allocation-plans-10-07.htm, accessed 12 October 2009.
26. UNFCCC [United Nations Framework Convention on Climate Change], "National Greenhouse Gas Inventory Data for the Period 1990-2009," submitted to the Subsidiary Body for Implementation, 16 November 2011, 9, 15. The data used in these two paragraphs are from the UNFCCC inventories of the six Kyoto-regulated greenhouse gases, because they use uniform standards across the largest number of countries. Unless otherwise noted, they exclude land use, land-use changes, and forestry because there are large problems with the reliability of the latter data (Michaelowa [see note 11], 32) and they are not a significant share of total emissions in most industrialized democracies. If land use and forestry changes were included, or if data from the German government or the European Environment Agency were used, the results would be only marginally different from those reported here.
27. By 2010, Britain's reduction, at 23.0 percent, once again slightly lagged Germany's 25.1 percent, with both figures not temperature-corrected; see Hans-Jochen Ziesing, "Milde Witterung lässt $CO_2$-Emissionen in Deutschland 2011 sinken," *Energiewirtschaftliche Tagesfragen*, 62 (April 2012): 30-37, here Table 5; Department of the Energy and Climate Change (UK), "2010 UK Greenhouse Gas Emissions, Final Figures," Statistical Release, 7 February 2012, Table 10.
28. UNFCCC (see note 26), 9. As I will discuss below, the eastern states of Germany resemble these cases, but Germany as a whole is appropriately seen as a Western case, since more than 80 percent of population and more than 70 percent of energy-related $CO_2$ emissions were in the western states in 1990; calculated from SAL [Statistische Ämter der Länder], *Umweltökonomische Gesamtrechnungen der Länder: Fläche und Raum, Tabellenteil* (Düsseldorf, 2008), Table 8.4.
29. Calculated from data in UNFCCC (see note 26), 15.
30. Malte Meinshausen, et al., "Greenhouse-gas Emission Targets for Limiting Global Warming to 2 Degrees C," *Nature*, 458 (30 April 2009): 1158-1163, here Figure 1a.
31. Martin Parry, Jason Lowe, and Clair Hanson, "Overshoot, Adapt and Recover," *Nature*, 458 (30 April 2009): 1102-1103, here 1102.
32. IPCC [Intergovernmental Panel on Climate Change], *Climate Change 2007: Synthesis Report* (N.p., 2008), 51; IPCC, *Climate Change 2007: Impacts, Adaptation and Vulnerability* (New York, 2007), 787; Nicholas Stern, *The Economics of Climate Change: The Stern Review* (New York, 2007), 57, 80.
33. James Risbey, "Some Dangers of 'Dangerous' Climate Change," *Climate Policy*, 6 (2006): 527-536.
34. Meinshausen, et al. (see note 30), 1158, assume a probability distribution for climate sensitivity similar to that in the IPCC's Fourth Assessment report, which has a current best estimate that a doubling of $CO_2$ concentrations would result in 3 degrees of warming (IPCC [see note 28], 38).
35. Remarkably, it assumes only 0.3 gigatons/year net CO2 emissions for the 2050-2099 period, an annual rate that is less than 1 percent of current emissions; see Meinshausen, et al. (see note 26), 1160, Fig. 2b; Malte Meinshausen and Bill Hare, "Twenty-six Questions and Answers in Regard to the Study 'Greenhouse-gas Emission Targets for Limiting Global Warming to 2°C,'" 4; available at http://www.pik-potsdam.de, accessed on 12 October 2009.
36. Including land use and forestry changes; Meinshausen, et al. (see note 30), 1160. If a 50 percent risk of two degrees of warming were acceptable, a budget of 2000 gigatons would be available.

37. Estimated from 2000-2004 data and assuming a linear trend over 2000-2010; data from IPCC, *Climate Change 2007: Synthesis Report: Summary for Policymakers* (N.p., 2008), 5.
38. This simple classification is very similar to that used for compiling most greenhouse gas emissions data; "industrialized democracies" here means the Annex I parties in the Kyoto Protocol except the "Economies in Transition," while "developing countries" means all non-Annex I countries.
39. Calculated from temperature-corrected data in Ziesing (see note 27), Tables 3, 5.
40. Calculated from data in the World Resource Institute's Climate Analysis Indicator Tool (WRI/CAIT), excluding land use and forestry changes; available at cait.wri.org, accessed 29 May 2009.
41. The 2000 gigaton budget, which carries a 50 percent risk of major climate change, would be used up just five years later, in 2026.
42. Calculated from U.S. Environmental Protection Agency and U.S. Census data.
43. Three years later, in 2019, the 2000 gigaton budget would be used up and the risk of major climate change would rise to 50 percent.
44. This accounts for emissions that have already occurred through 2010. For simplicity's sake, I leave aside the important issue of the cumulative effect of historical emissions, which would imply the need for even greater cuts in Germany's emissions.
45. This assumes 11.0 gigatons of $CO_2$ absorbed by the Earth each year; see IPCC, *Special Report on Land Use, Land-Use Change And Forestry* (N.p., 2000), 5, Table 2; Jason Venetoulis and John Talberth, "Refining the Ecological Footprint," *Environment, Development and Sustainability*, 10 (2008): 441-469, here 452. To produce emissions only at the rate that the Earth can absorb, the global fair share would be 1.38 tons $CO_2$/person-year (again assuming a global population of 8 billion), compared with Germany's emissions of 9.8 tons $CO_2$/person in 2010 (Ziesing [see note 27], Table 3).
46. Data from Ziesing (see note 27), Table 5. This adjusts for year-to-year temperature differences, which strongly affect heating fuel consumption.
47. The latter estimate is based on the scenario developed by the Environmental Defense Fund, which is based on the IPCC's mid-range B2 scenario, involving intermediate population growth, economic growth, and technological development, and local solutions to sustainability problems. Kyle Meng, et al., "Constructing a Post-2012 Pathway," paper presented at the International Energy Workshop, Stanford University, Stanford, Calif., 25-27 June 2007, 9-10, Fig. 4; IPCC, *Synthesis Report* (see note 32), 44. See Table 1 for details.
48. Emissions data, which include land use and forestry changes, are from WRI/CAIT, except those for developing countries are from Meng et al. (see note 47).
49. Calculated from WRI/CAIT data. Emissions assumptions for the industrialized democracies and post-communist countries are the same as in the previous note, and would total 640 gigatons over the 2000-2049 period, leaving 860 gigatons for the developing countries. This assumes a 25 percent risk of major climate change; with a 50 percent risk, developing countries could emit 27.2 gigatons per year on average, an increase of only 9 percent over their 2005 emissions rates.
50. Calculated from WRI/CAIT data, including land use and forestry changes.
51. FRG [Federal Republic of Germany], *Fourth National Report by the Government of the Federal Republic of Germany (4th National Communication),* Report under the Kyoto Protocol to the United Nations Framework Convention on Climate Change, July 2006.; available at at unfccc.int/resource/docs/natc/gernc4.pdf; FRG, *Fifth National Report by the Government of the Federal Republic of Germany (5th National Communication),* Report under the Kyoto Protocol to the United Nations Framework Convention on Climate Change, November 2010; available at at http://unfccc.int/resource/docs/natc/deu_nc5_resubmit.pdf.
52. Schleich, et al. (see note 24).
53. BMU [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit], *Erneuerbare Energien in Zahlen* (Berlin, 2011).

54. IFEU [Institut für Energie- und Umweltforschung and Öko-Institut], "Klimaschutzpotenziale der Abfallwirtschaft," Berlin, January 2010; available at http://www.bde-berlin.org/wp-content/pdf/2010/klimaschutzpotentiale.pdf, accessed 24 May 2012.
55. Stefan Bach, Michael Kohlhaas, and Barbara Praetorius, "The Effects of the Ecological Tax Reform in Germany," *Economic Bulletin*, 38 (2001): 165-170; Michael Kohlhaas, "Gesamtwirtschaftliche Effekte der ökologischen Steuerreform," research report, DIW Berlin, Abteilung Energie, Verkehr, Umwelt (2005).
56. Hans-Joachim Ziesing, "Kräftiger Anstieg der $CO_2$-Emissionen in Deutschland," *Energiewirtschaftliche Tagesfragen*, 61 (2011): 61-68, here Fig. 3.
57. See, Schleich, et al. (see note 24); Geoffrey Kelly, "National Policy Choices for an International Problem: Case Studies in Greenhouse Policy," Ph.D. thesis, Faculty of Commerce, University of Wollongong, Australia, 2008.
58. Unless otherwise stated, changes in emissions refer to this period and numbers refer to the Kyoto greenhouse gases in $CO_2$ equivalent. For Germany's emissions decline, it uses the temperature-adjusted data in Ziesing (see note 27), Table 5, which show a decline of 341 Mt or 27.2 percent from 1990 to 2010.
59. Wolfgang Eichhammer, et al., "Greenhouse Gas Reductions in Germany and the UK," report prepared for the 6th Conference of the Parties (COP6), Bonn, 16-27 July 2001, 39; calculated from data in BMU (see note 53), 12, 16, 20, 22.
60. FRG, *Fourth National Report* (see note 51), 135; FRG, *Fifth National Report* (see note 51), 57, 88-89, 100; Eichhammer, et al. (see note 59), 15, 20.
61. Other relatively successful policies that have received little academic attention include a variety of transportation policies (16 Mt/year), industrial and commercial ordinances on heating and energy saving (13 Mt/year), and policy-induced reductions of methane emissions in coal mining (9 Mt/year).
62. Bach, Kohlhaas, and Praetorius (see note 55), 21; Kohlhaas (see note 55), 14; FRG, *Fourth National Report* (see note 51), 107, 121; FRG, *Fifth National Report* (see note 51), 142, 158, 160.
63. Ziesing (see note 56), Fig. 3.
64. Calculated from data in Ziesing (see note 56), Tables 3, 5.
65. Jennifer Hunt, "The Economics of German Reunification," in *The New Palgrave Dictionary of Economics*, second ed, eds., Steven Durlauf and Lawrence Blume. (New York, 2008); Michael Burda and Jennifer Hunt, "From Reunification to Economic Integration," *Brookings Papers on Economic Activity*, Issue 2 (2001), 1-71, here 9, 11.
66. Schleich, et al. (see note 24), 378.
67. Eichhammer, et al. (see note 59), 8, 10.
68. Watanabe and Mez (see note 11), 114-115; Hatch (see note 11), 12-13.
69. Weidner (see note 11), 9, n. 13.
70. Eichhammer, et al. (see note 59), 21.
71. Calculated from data in SAL (see note 28), Table 8.4; Volker Hannemann, "Länderübersicht," *Statistisches Jahrbuch Deutscher Gemeinden*, 79 (1992): 482-97, here 482, 490.
72. BMU (see note 53), 13, 16.
73. This estimate is based on BMU (see note 53), 12, 16, 20, 22, with adjustments to subtract renewable energy production in 1990.
74. See Umweltbundesamt (see note 16), 37; Weidner and Mez (see note 2), 369.
75. Eichhammer, et al. (see note 59), 20; FRG, *Fifth National Report* (see note 51), 57.
76. IFEU (see note 54), 64, 85.
77. Eichhammer, et al. (see note 59), 20; Axel Michaelowa, "German Climate Policy between Global Leadership and Muddling Through," in *Turning Down the Heat: The Politics of Climate Policy in Affluent Democracies*, eds., Hugh Compston and Ian Bailey (New York, 2008), 144-163, here 154.
78. Schleich, et al. (see note 24), 373; FRG, *Fourth National Report* (see note 51), 135; FRG, *Fifth National Report* (see note 51), 88-89, 100.

79. This is the average of three estimates by the German government and by the German Institute for Economic Research (DIW), which range from 12.2 to 24 Mt/year (FRG, *Fourth National Report* [see note 51], 107; Bach, Kohlhaas, and Praetorius [see note 55], 21; Kohlhaas [see note 55], 14). These sources may underestimate the ecotax's overall effects to the extent that higher fuel prices spurred long-term improvements in the fuel efficiency of vehicles. Nevertheless, state vehicle tax increases also contributed to that outcome, and about half of the recent fuel efficiency gains occurred before either of those measures was implemented. See: Martin Jänicke, "Ecological Modernisation and the Creation of Lead Markets," FFU Report 03-2002, Environmental Policy Research Center, Free University of Berlin, 2002, 112; Umweltbundesamt (see note 16), 53; Umweltbundesamt, *Environmental Data for Germany: Environmental Indicators, 2007 edition* (Berlin, n.d. [2007]), 22.
80. OECD, "Environmental Expenditure and Taxes," ch. 14 in *Environmental Data Compendium, 2006-2007* (Paris, 2007), 15.
81. Kelly (see note 57), 153-154.
82. Watanabe and Mez (see note 11), 122.
83. FRG, *Fourth National Report* (see note 51), 116-117, 121-122; cf. Eichhammer, et al. (see note 59), 15. The effects of the agreements are difficult to evaluate, however, partly because of inadequacies in reporting and monitoring and because it is difficult to judge results relative to business-as-usual scenarios. See: Susanne Rupp and Ian Bailey, "German Climate Change Policy Report," ESRC project Climate Change and Industry Reactions to New Environmental Policy Instruments, Internal Report, University of Plymouth, August 2003, 23, 26; Kelly (see note 57), 151, 163.
84. Ian Bailey, "`Voluntary' Environmental Agreements and Climate Policy," paper presented at the Corporate Responsibility Research Conference, Dublin, 3-5 September 2006, 11; Ziesing (see note 11), Table 4; Rupp and Bailey (see note 83), 22-23.
85. Kelly (see note 57), 163; Weidner and Mez (see note 2), 366.
86. Bailey (see note 84), 7.
87. Umweltbundesamt (see note 16), 43-44; Watanabe and Mez (see note 11), 123.
88. IHS (see note 25); FRG, *Fifth National Report* (see note 51), 158.
89. SRU [Sachverständigenrat für Umweltfragen], "Kontinuität in der Klimapolitik – Kyoto-Protokoll als Chance: Stellungnahme," (2005), 11; available at www.umweltrat.de, accessed 10 May 2012.
90. AFGW [Arbeitsgemeinschaft für Wärme und Heizkraftwirtschaft], *Arbeitsbericht 2003* (Frankfurt, 2003), 5; AFGW, *Branchenreport 2006* (Frankfurt, 2006), 7.
91. Umweltbundesamt, "Unecological Subsidies Cost 48 Billion Euros," press release No. 32/2010; available at www.umweltbundesamt.de, accessed 24 May 2012; Arbeitsgruppe Energiebilanzen, *Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland: 1990 bis 2010* (Berlin, 2011), Table 3.
92. Ziesing (see note 56), Fig. 3.
93. Hence, in the aggregate, $CO_2$ emissions from household heating declined 21 percent, those from electricity consumption by all sectors declined 18 percent, and those from road traffic declined 3 percent from 1990 to 2010 (Ziesing [see note 27], Table 4).
94. From 1991 to 2009. See BVBS [Bundesministerium für Verkehr, Bau und Stadtentwicklung], *Verkehr in Zahlen 2010/2011* (Hamburg, 2011), 302-3; Umweltbundesamt, *Environmental Data* (see note 79), 24.
95. SRU (see note 89), 13; ACEA [European Automobile Manufacturers' Association], *EU Economic Report* (Brussels, 2011), 20.
96. Over the 1990-2010 period; ACEA (see note 95), 20.
97. In passenger-kilometers over the 1991-2009 period; see: BVBS, *Verkehr in Zahlen 2008/2009* (Hamburg, 2008), 212-213; BVBS (see note 94), 219.
98. Over the 1991-2009 period; see: BVBS (see note 97), 212-213; BVBS (see note 94), 219, 340.
99. BVBS (see note 97), 236; BVBS (see note 94), 245.

100. Umweltbundesamt, "Spezifische Emissionen des Straßenverkehrs;" available at http://www.umweltbundesamt-daten-zur-umwelt.de/umweltdaten/public/theme.do, accessed 22 May 2012.
101. Calculated from data in Sachverständigenrat für Umweltfragen, *Umwelt und Strassenverkehr: Sondergutachten* (2005); available at www.umweltrat.de, 75; BVBS (see note 97), 187, 189, 203.
102. From 1991; see Umweltbundesamt (see note 94), 23.
103. BVBS (see note 97), 237.
104. Ziesing (see note 27), Table 4.
105. SRU (see note 89), 12; Ziesing (see note 27), Table 4. These data are not adjusted for temperature differences, which strongly affect household fuel use. Nevertheless, this matters little compared with the size of the decline.
106. FRG, *Fourth National Report* (see note 51), 134.
107. Both trends beginning in 1990, with the former going through 2007 and the latter through 2009; see: Institut für Städtebau, Wohnungswirtschaft und Bausparwesen, "Pro-Kopf-Wohnfläche weiter gestiegen – Saarland mit 48 Quadratmetern weiterhin Spitze," *Hausbau Information*, 2008, 16 (6 October 2008), 2; Bundesministerium für Wirtschaft und Technologie, *Energie in Deutschland* (Berlin, 2010), 23.
108. The government's "Energie Wende," announced in 2011, targeted electricity consumption for the first time; it called for a 10 percent reduction by 2020, but implementation is uncertain; see Der Spiegel, "Altmaier zweifelt an Prognosen der Regierung," *Der Spiegel Online*, 15 July 2012; available at http://www.spiegel.de/wirtschaft/soziales/energiewende-altmaier-zweifelt-an-zielen-zum-stromverbrauch-a-844449.html, accessed 16 July 2012.
109. AGEB (see note 91), Tables 4, 4.1, 4.2.1., 4.2.2; Sachverständigenrat für Umweltfragen, *Umweltgutachten 2008: Umweltschutz im Zeichen des Klimawandels (Hausdruck),* (2008); available at www.umweltrat.de, 125; Ziesing (see note 27), Table 4. The looming phase-out of nuclear power did not strongly affect greenhouse gas emissions in this sector, since nuclear power generation fell by an amount equal to only 0.9 percent of total primary energy consumption in this period.
110. For example, in the terms of the above analysis, Sweden, with per-capita emissions of 7.2 tons $CO_2$eq/person-year, would require additional, immediate emissions cuts of 58 percent in order to attain the fair-share level that every country would need to adopt in order to avoid two degrees of warming. At Sweden's rate of emissions reduction over the last two decades (totaling a relatively large 17.2 percent), it would still take another eighty-seven years for it to attain fair-share per-capita emissions.
111. Amanda Lowenberger, et al., "The Efficiency Boom," Report Number ASAP-8/ACEEE-A123, American Council for an Energy-Efficient Economy, March 2012; Roger Karapin, "Wind-Power Development in Germany and the U.S.: Multiple Streams, Advocacy Coalitions, and Turning Points," in *The Politics of Ecology: The Comparative Study of Environmental Politics and Policy* [tentative title], ed. Andreas Duit (Cambridge, forthcoming 2013); U.S. Energy Information Administration data.
112. OECD (see note 80), Tables 3B, 3C; British figures calculated from World Bank data; available at datafinder.worldbank.org, accessed 14 January 2010.
113. Bang (see note 17); Hatch (see note 11); Hatch (see note 22); Jänicke (see note 2); Michaelowa 2003 (see note 11); Pehle (see note 22); Umweltbundesamt (see note 16); Watanabe and Mez (see note 11); Weidner and Eberlein (see note 16).
114. Eichhammer, et al. (see note 59), 39.
115. Karapin (see note 15).
116. Jänicke and Weidner, *National Environmental Policies* (see note 4), 10-11; Jahn, "Environmental Performance" (see note 4), 123-125; Eric Neumayer, "Are Left-wing Party Strength and Corporatism Good for the Environment?" *Ecological Economics* 45 (2003): 203-220, here 218-219.

117. Staffan Jacobsson and Volkmar Lauber, "The Politics and Policy of Energy System Transformation," *Energy Policy*, 34 (2006): 256-276, here 265.
118. Elim Papadakis, "Green Issues and Other Parties," in *The Greens in West Germany*, ed., Eva Kolinsky (New York, 1989), 61-86; Miranda Schreurs, "Domestic Institutions and International Environmental Agendas in Japan and Germany," in *The Internationalization of Environmental Protection*, eds., Miranda Schreurs and Elizabeth Economy (New York, 1997), 134-161, here 153; Helmut Weidner, "Environmental Policy and Politics in Germany," in *Environmental Politics and Policy in Industrialized Countries*, ed., Uday Desai (Cambridge, 2002), 149-202, here 154.
119. Bundesministerium für Umweltschutz, *Entwicklung der erneuerbaren Energien in Deutschland im Jahr 2011* (Berlin, 2012), 7, 11.
120. Temperature-corrected estimate from data provided by Hans-Joachim Ziesing and data in: Ziesing (see note 27), Table 4; Arbeitsgruppe Energiebilanzen (see note 91), Tables 4.2.1, 4.2.2; and Arbeitsgruppe Energiebilanzen, *Ausgewählte Effizienzindikatoren zur Energiebilanz Deutschland: Daten für die Jahre von 1990 bis 2011* (Berlin, 2012), Table 6.2.