Renewable Energy Policy in Germany: An Overview and Assessment

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Renewable energy technologies have deployed rapidly in Germany since 1990 largely as a result of energy policies adopted by the German government and the European Union. For example, installed wind capacity has grown by more than 2000% since 1990, biomass by more than 500%, and solar photovoltaic installations by more than 15,000%. While the 1990 baseline for each of these technology areas was very low, the steady rise of renewable energy in Germany is noteworthy nonetheless.

The rising importance of environmental issues in the German electorate, initially in the 1970s and 1980s, and legislation such as the 1990 Electricity Feed Law and 2000 Renewable Energy Law played major roles in advancing the deployment of renewable energy technologies. These laws mandated the purchase of renewably generated electricity by electric utilities and also offered large subsidies and government loans to renewable power producers. A 1997 Directive on Renewable Energy Sources adopted by the European Union (EU) also contributed to the cause of renewable energy by aiming to boost the renewable share of the electricity generating fuel mix to 22% by 2010. Similarly, the EU’s ratification of the Kyoto Protocol has given all EU member states additional legal incentives to reduce their domestic greenhouse gas emissions through the use of renewable energy. Renewable energy technologies are part of a broader long-term German energy strategy to reduce greenhouse gas emissions and other environmental impacts of energy use, to curtail dependence on the oil and gas imports that now satisfy some 62% of German energy demand, and to contribute to German economic growth via high technology exports.

The successes of renewable energy in Germany over the past decade must be balanced with other considerations. For example, some community and environmental groups are mounting opposition to the continued expansion of wind power installations because of their impacts on the landscape and bird populations, due to the noise generated by wind turbines, and due to concerns regarding the transparency of the siting and permitting processes for new wind plants. Increasingly, suboptimal sites have been developed for renewable energy production as the highest quality (and lowest cost) sites both onshore and offshore have been exploited. Also, Germany’s gas, coal, and electric power industries have objected to mandates for the purchase of more expensive renewable power and to the subsidies granted to renewable producers. In addition, the accelerated deployment of renewable energy technologies in Germany has paralleled a sharp decline in investment in energy research and development by the German government, prompting concerns that early deployment of renewable technologies may come at the expense of future generations of energy technologies. While renewable energy is likely to make further gains in Germany and throughout Europe in the near- to mid-term, domestic growth of renewable energy may be slowed in the longer term by political pressures and technological limitations.
1. Introduction

The growth of renewable energy in Germany has often been cited as a model success story.¹ The German government launched a comprehensive series of promotions for renewable energy in the early 1990s, which has since been augmented with additional legislation and policy actions to increase renewable energy use.² As this paper discusses, most of these policies were embedded in a larger set of environmental, economic, and security policy considerations. For example, growing environmentalism in the German electorate, regulatory obligations domestically and at the level of the European Union, and concern over rising energy import dependence all played some part in spurring the adoption of aggressive renewable energy policies. That these considerations also amounted to a significant evolution in German energy and technology policy—from technology policies favoring longer-term R&D and later deployment to technology policies encouraging earlier adoption of existing technologies via market incentives—appears not to have been an explicit aim of the German government.

The German approach has combined ongoing R&D efforts with a variety of policy instruments (taxes, credits, standards, etc.), favorable electricity feed laws, export promotion programs, and government secured loans for renewable energy projects. These policies have helped Germany to attain a leading position in many aspects of renewable energy use. For example:

- World leadership in installed wind capacity – 13,512 MW as of October, 2003, or approximately 40% global capacity;
- An installed PV capacity second only to Japan – approximately 350 MW;
- European leadership in biodiesel sales – 550,000 tonnes per year as of the end 2002;
- The largest European market for solar heating systems – 4.75 million square meters installed domestically as of December, 2002;
- A substantial green electricity share – green electricity, including hydropower, represents approximately 9% of electricity generating capacity.

² Total electricity consumption in Germany was 581 TWh in 2002; renewable sources accounted for 44.3 TWh or 7.6% of total electricity consumption. See: Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, “Erneuerbare Energien in Zahlen: Nationale und Internationale Entwicklungen,” November 2003, p. 12.
The rapid penetration of wind energy in particular in the electricity generation fuel mix over the past decade has been attributed in large part to the passage of electricity feed laws obligating power providers to purchase renewably-generated power from producers at fixed rates. Improvements in wind turbine technology, in conjunction with this and other favorable legislation, moved wind to the forefront among renewable energy options. Between 1990 and 2004 the average manufacturing cost of wind turbines in Germany fell by 50%. Lower costs may be attributable to a combination of technical innovations in the wind industry and innovations in other industries (e.g., materials and computers).

Government subsidies to wind and other renewable energy producers have also played a major part in accelerating the growth of renewable energy. While mandating emissions reductions, a combination of direct subsidies to renewable energy producers, low-interest loans to investors, and renewable portfolio standards have been instituted with the aim of boosting renewable sources in the electricity supply mix to 21% by 2010. In December 2003, the government issued a cabinet decision prolonging subsidies to alternative power producers for an unspecified time period; however, the decision also noted that subsidy levels would decline by 2% annually to encourage competition among renewable technology manufacturers.

Even though renewable energy has grown rapidly in Germany, its contribution to total electricity consumption remains relatively small. As Figure 1 shows, domestic renewable energy production is only a fraction of total electricity demand. The substantial growth in renewable energy production has not kept pace with a six percent increase in Germany’s total electricity consumption since its low point in 1993. Thus, the substantial increases in renewable energy use have not reduced conventional electricity demand.

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4 U.S. Department of energy, Energy Information Administration, “Country Analysis Brief: Germany,” available from http://www.eia.doe.gov/emeu/cabs/germany.html. Note that the “Other Renewables” category consists of biomass predominantly. Note also that Germany both imports and exports electricity. Net imports vary from year to year and are considered in calculating total consumption.
While the German government has invested more than 3.5 billion Euros in renewable energy R&D since 1990, its overall approach to renewable energy has evolved to place greater emphasis on technology deployment activities. As Figure 2 shows, renewable energy R&D programs have received more consistent government funding than other energy R&D program areas since 1990. Overall government support for energy R&D has fallen sharply in Germany over the past two decades—by approximately 76% since 1981. The primary cause of this overall decrease has been a massive reduction in nuclear energy R&D, which dominated the German energy R&D portfolio in the early 1980s.

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5 Sources: Bundesministerium fuer Wirtschaft und Arbeit, Energie Daten 2003: Nationale und Internationale Entwicklungen, available from http://www.bmwa.bund.de/bmwa/generator/Navigation/Service/bestellservice.did=13782.html; and Verband der Elektrizitaetswirtschaft, “Weiniger Stromimporte,” available from http://www.strom.de/wysstr/stromwys.nsf. The author calculated German electricity consumption by adding net imports/subtracting net exports to gross electricity production for the years 1991-2002. In Figure 1, net imports and exports are reflected in the conventional generation category only. Considering that Germany has been a net power exporter for most of the years shown, Figure 1 may slightly understate the growth of conventionally-generated electricity and/or slightly overstate the growth of renewables.

6 The German government combines renewable energy and energy efficiency programs (termed “rational energy use” in Europe) in a single administrative and budget category. Thus, the data line shown in Figure 2 reflects trends in both renewable energy and energy efficiency R&D. Note also that hydrogen and fuel cell R&D programs, which are categorized as fossil energy R&D programs in some countries, are also included in the German renewable energy R&D budget.
Figure 2. German Federal Government Support for Energy R&D 1990-2002

As Figure 3 shows, funding for individual programs in the government’s renewable energy portfolio has varied significantly from year to year since the early 1990s.

Figure 3. German Federal Government Support for Renewable Energy R&D by Program Sub-Area, 1990-2002

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In particular, the decline in support for solar photovoltaics and biomass R&D provides a counterpoint to the host of other policy measures adopted to spur the adoption of these technologies. This adoption of deployment policies with a protracted reduction in R&D expenditures suggests an increasing preference for the deployment of existing renewable energy technologies in the near term, along with any learning-by-doing and induced private innovative activity from this deployment, over a publicly-financed R&D approach targeting a next generation technologies for deployment at a later date. Landmark legislation such as the 1991 Energy Feed Law and 2000 Renewable Energy Law (discussed later in this paper) have had an accelerating effect on the deployment of renewable energy technologies since 1990 even though renewable energy R&D budgets in several key technology program areas have been erratic over the same period. Renewable technology deployment targets coupled with incentives such as government subsidies to renewable electricity producers have propelled the rapid growth of wind and solar thermal power, and, increasingly, to broader deployment of biomass and photovoltaic systems.9

There have been noteworthy exceptions to this approach, however. Hydrogen and fuel cell R&D and, to a lesser extent, geothermal R&D programs have experienced sharp funding increases in recent years. Intensive R&D is still needed in these areas to bring technologies closer to commercial viability and broad market deployment. R&D funding cuts have had the greatest impact in mature technology areas (e.g., fossil fuels). Nuclear technology R&D has also been sharply reduced, primarily because of Germany’s intended phase out of all nuclear power by 2020.10

The remaining sections of this paper address several dimensions of renewable energy policy in Germany. Section 2 presents a historical overview of the development of renewable energy in Germany, focusing on major legislation, projects, and initiatives undertaken since the 1970s. It shows that while Germany has a long history of support for renewable energy projects, it is only since 1990 that renewable energy has played a consequential role in Germany’s fuel mix. Section 3 explains the evolution of German renewable energy policy, focusing principally on domestic and international political drivers. Pressures from domestic political actors, such as an ascendant Green, and obligations to the European Union, for example, have played major formative roles in renewable energy policy. Section 4 considers future challenges to the growth of renewable energy in Germany. While domestic political pressures played a catalyzing role for renewables in the 1990s, opposing political pressures may place limitations on them in coming years. Section 5 looks at the overall effectiveness of Germany’s major renewable energy policies, and Section 6 offers a summary and conclusion.

9 Bundesministerium fuer Umwelt, Naturschutz, und Reaktorsicherheit, “Entwicklung der erneuerbaren Energien, Stand August 2003.”
2. History of Support for Renewable Energy in Germany

Government sponsorship of renewable energy was spurred initially by energy security concerns during the 1970s. The energy crises of 1973-74 and 1979-80 had severe economic impacts on Germany as on most other industrialized countries; consequently, renewable energy sources were promoted as a potential means of alleviating the risks associated with high fossil fuel import dependence. The parallel development of environmental awareness and the emergence of environmental political parties in Europe provided an equally powerful rationale for government investment in renewable energy sources. By the early 1990s, environmental concerns, particularly global climate change, had become principle drivers of renewable energy policy. Germany has been a proponent of international policy action to address climate change and has adopted a broad set of domestic actions to curtail its greenhouse gas emissions. For example, as part of the European Union’s commitment under the Kyoto Protocol, Germany agreed to a 21% reduction in greenhouse gas emissions from 1990 levels within the period 2008-2012. Consequently, renewable energy sources and accelerated deployment of renewable energy technologies are seen by the German government as playing a central role in meeting its voluntary greenhouse gas reduction goals.

Promotion of renewable energy technology development in Germany began with federal government R&D support for wind turbine development in 1974. The government’s large-scale wind plant project (GROWIAN) developed the largest wind turbine ever before built, but the technology failed due to limitations in manufacturing and system integration. The GROWIAN plant was dismantled in 1987 and is regarded as an economic failure, despite some technical successes and contributions to the development of wind power in Germany.

Germany has relied on a combination of five primary policy instruments for the promotion of renewable energy:

14 GROWIAN is an acronym for “Grosse Wind Anlage” or “large wind system.”
• Direct investment in R&D;
• Direct subsidies;
• Government-sponsored loans;
• Tax allowances;
• Subsidies for operational costs/feed-in tariffs.

Figure 4. Renewable Electricity in Germany: Installed Capacity 1990-2003 (Selected Energy Technology Areas)

A federal Electricity Feed Law (StrEG) was adopted in 1991 and became the most important instrument for the promotion of renewable energy in Germany during the 1990s. It obligated public utilities to purchase renewably-generated power from wind, solar, hydro, biomass and landfill gas sources, on a yearly fixed rate basis, based on utilities’ average revenue per kWh. Remuneration to wind producers was set at 90% of the average retail electricity rate; for other renewable power providers, compensation was set at 65-80%, depending on plant size, with smaller plants receiving the higher subsidy level. The StrEG effectively subsidized the operation of commercial wind installations at 4.1 Euro cents/kWh, and jump-started wind power’s market breakthrough in the 1990s, illustrated in Figure 4 (above). In addition, investment in wind power installations was also subsidized by a domestic, state-owned development bank, the Deutsche Ausgleichsbank, which offered low-interest, government guaranteed loans for new wind power development.16

The successor to the StrEG was Germany’s Renewable Energy Law (EEG), adopted in April 2000. The EEG aims to facilitate a doubling of renewable energy’s 1997 share in the power generation fuel mix by 2010—to a minimum of 12.5%. Unlike that of the

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StrEG, the EEG’s remuneration system is not based on average utility revenue per kWh sold, but rather on a fixed, regressive feed-in tariff for renewable sources. Low-cost renewable energy producers are compensated at lower rates than higher-cost producers, providing strong incentives for the development and operation of renewable energy installations on lower-quality sites.17 Also, under the EEG, grid operators are obligated to purchase power from local producers; a nation-wide equalization scheme has been implemented to reduce the cost differentials paid by grid operators in different parts of the country for the purchase of renewably-generated electricity.18

As Table 2 shows, the EEG also increased the rates utilities pay to renewable energy producers, in most cases by 10%—but by as much as 500% in the case of solar photovoltaic power. The Renewable Energy Supply Act subsidized most renewable energy sources and obligated utilities to buy power from renewable producers, but succeeded mainly in promoting wind; while solar PV and solar thermal energy deployment has also grown significantly, solar technologies continue to have difficulty competing with fossil fuels and other renewables—even at the highly-subsidized rates shown in Table 2 (below).19 Hence, while the deployment policies have resulted in a dramatic expansion in the deployment of renewables in general, they have had asymmetric impacts, promoting those technologies that are currently most economically competitive. The fact that Germany’s deployment policies favor those renewable energy technologies that are most commercially viable suggests that the German government places high value on technology deployment for near-term emissions reductions.

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17 The EEG guarantees renewable energy producers premium prices for the power they generate. For example, wind turbines are granted a premium price of 9 Euro cents per kWh for the first five years of operation. Thereafter, site quality is evaluated against predefined performance standards. If a site yields at least 150% of the standard, then the guaranteed tariff drops to 6 Euro cents/kWh. For sites yielding less than 150%, the 9 cent rate is extended by two months for every 0.75% that the yield falls below the 150% mark. By this formulation, weaker sites are compensated at a rate that ensures continued operation, while stronger sites are not over-compensated. These higher rates also provides incentives for the development of inland sites that are less windy than coastal areas and allow inland wind developers access to credit that would otherwise not be available. See: Paul Gipes, “German Electricity Feed Law Policy Overview,” available from http://www.wind-works.org


19 Bechberger and Reiche, 52.
Table 2. Proposed Feed-in Tariffs for Selected Power Generation Sources (in Euro ct/kWh), 2002-2004

<table>
<thead>
<tr>
<th>Source</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro (up to 500 kW)</td>
<td>7.67</td>
<td>7.67</td>
<td>7.67</td>
</tr>
<tr>
<td>Hydro (500 kW-5 MW)</td>
<td>6.65</td>
<td>6.65</td>
<td>6.65</td>
</tr>
<tr>
<td>Landfill gas (up to 500 kW)</td>
<td>7.67</td>
<td>7.67</td>
<td>7.67</td>
</tr>
<tr>
<td>Landfill gas (500 kW-5 MW)</td>
<td>6.65</td>
<td>6.65</td>
<td>6.65</td>
</tr>
<tr>
<td>Biomass (up to 500 kW)</td>
<td>10.13</td>
<td>10.03</td>
<td>9.93</td>
</tr>
<tr>
<td>Biomass (500 kW-5 MW)</td>
<td>9.11</td>
<td>9.02</td>
<td>8.93</td>
</tr>
<tr>
<td>Biomass (5 MW-20 MW)</td>
<td>8.60</td>
<td>8.52</td>
<td>8.43</td>
</tr>
<tr>
<td>Geothermal (up to 20 MW)</td>
<td>8.95</td>
<td>8.95</td>
<td>8.95</td>
</tr>
<tr>
<td>Wind (onshore or offshore)</td>
<td>8.96</td>
<td>8.83</td>
<td>8.70</td>
</tr>
<tr>
<td>Solar PV (5 MW)</td>
<td>48.09</td>
<td>45.68</td>
<td>43.40</td>
</tr>
</tbody>
</table>

The election of Germany’s Red-Green coalition government in 1998 brought with it additional policies and legislation promoting the growth of renewable energy. For example, the 1999 Ecological Tax Reform (ETR) initially increased the taxes on motor fuels, fuel oils, and natural gas, and also levied an electricity tax across all sectors. These taxes have increased in subsequent years. The ETR has helped to broaden the use of biofuels, which are exempt from taxation under the law, but has had a neutral effect on wind, solar, and other sources of renewable electricity, since all electricity providers are subject to the ETR power levy.

The coalition government also introduced the 100,000 Solar Roofs Program (HTDP) in 1999. The program aimed to increase solar PV electricity generation by subsidizing the installation of new solar panels with capacity of 3kWp or higher. With a 510 million Euro grant, HDTP helped installed PV capacity to grow from 50 MW in 1998 to 350 MW in 2003. The Program was expected to generate 1.3 billion Euros in private investment and also served a key industrial policy goal. HDTP was designed to enhance the competitiveness of German PV manufacturers and place them at the leading edge of a burgeoning global solar market. The extent of its success in meeting this goal will be addressed later.

In 1999, the new government also introduced the Market Incentive Program (MAP), which offered government grants totaling 203 million Euro in 2003 alone for the commercialization and deployment of renewable energy systems. 30 million Euros are earmarked for export promotion. The German government considers MAP to be one of its most effective current renewable energy promotion programs, particularly since funds from the program may be leveraged with other government funds.

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20 H.J. de Vries, Bechberger and Reiche, 54.
21 Bechberger and Reiche, 50.
3. Explaining the Evolution of Germany’s Renewable Energy Policy

The evolution of Germany’s approach to the promotion of renewable energy appears to have been more implicit than explicit. Even though the resources devoted to the deployment of renewable energy technologies now exceeds those directed toward renewable energy R&D by more than 400%, this distribution apparently has resulted from a variety of political and economic developments that have become more prominent factors in the German government’s decision-making than on an expressed preference for market-based technology policies. Two key sets of factors—policy developments at the European Union level and developments in domestic politics and policy—are discussed below.

3.1 Policy Developments at the European Union Level

As a member of the European Union, Germany is obligated to comply with EU-level legislation and directives. Since Germany is also one of the EU’s most influential countries, its compliance with EU policies is also important to the legitimacy and prestige of both entities.

EU policies have imposed burdens disproportionately on member states. For example, the 1997 White Paper “Energy for the Future: Renewable Sources of Energy,” states that the “overall EU target of doubling the share of renewables to 12% by 2010 implies that Member States have to encourage the increase of RES [renewable energy sources] according to their own potential.” As one of Europe’s largest and most technologically developed countries, expectations for Germany within the EU are great as Table 3 shows.

More recently, legislation passed by the European Parliament has obligated member states to adopt national targets for the expansion of renewable energy’s share in Europe’s fuel mix. The 2001 Directive on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market (RES-E) aims to increase renewable energy’s share to 12% of primary energy consumption in the EU and to boost renewable sources to 22% of electric power production by 2010. The Directive mandates that “Member States shall take appropriate steps to encourage greater consumption of electricity produced from renewable sources in conformity with the national indicative targets referred to in paragraph 2 [Art.3.2 of the RES-E].” Although Germany had passed its Renewable Energy Law (EEG) prior to the passage of the EU Directive, EU

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23 The author made this rough estimate of the ratio of deployment-to-R&D funding based on the German government data presented in this paper in Figure 1 and Table 3.
policies and consultations were important considerations for German policy makers in drafting the domestic law.26

Table 3. Reference Values for EU Member States’ National Targets for the Contribution of Renewable Energy Sources to Gross Electricity Consumption by 201027

<table>
<thead>
<tr>
<th>Country</th>
<th>TWh 1997</th>
<th>% Electricity Fuel Mix 1997</th>
<th>% Electricity Fuel Mix 2010 Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>0.86</td>
<td>1.1</td>
<td>6.0</td>
</tr>
<tr>
<td>Denmark</td>
<td>3.21</td>
<td>8.7</td>
<td>29.0</td>
</tr>
<tr>
<td>Germany</td>
<td>24.91</td>
<td>4.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Greece</td>
<td>3.94</td>
<td>8.6</td>
<td>20.1</td>
</tr>
<tr>
<td>Spain</td>
<td>37.15</td>
<td>19.9</td>
<td>29.4</td>
</tr>
<tr>
<td>France</td>
<td>66.00</td>
<td>15.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.84</td>
<td>3.6</td>
<td>13.2</td>
</tr>
<tr>
<td>Italy</td>
<td>46.46</td>
<td>16.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.14</td>
<td>2.1</td>
<td>5.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.45</td>
<td>3.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Austria</td>
<td>39.05</td>
<td>70.0</td>
<td>78.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>14.30</td>
<td>38.5</td>
<td>39.0</td>
</tr>
<tr>
<td>Finland</td>
<td>19.03</td>
<td>24.7</td>
<td>31.5</td>
</tr>
<tr>
<td>Sweden</td>
<td>72.03</td>
<td>49.1</td>
<td>60.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>7.04</td>
<td>1.7</td>
<td>10.0</td>
</tr>
<tr>
<td>EU Total</td>
<td>338.41</td>
<td>13.9</td>
<td>22</td>
</tr>
</tbody>
</table>

The European Commission is promoting the deployment of renewable energy technologies across the EU to address three main energy policy challenges. First, under the Kyoto Protocol, it has agreed to EU-wide greenhouse gas emissions reductions of 15% from 1990 levels in the first reporting period, 2008-2012. This aggregate reduction target is disparately divided among EU member states; while Germany has accepted a 21% reduction goal, other countries obligations are more modest. A few countries, such as Greece and Portugal, are permitted emissions increases under the “EU Umbrella.” Just as member states are encouraged to adopt renewable energy technologies “according to their own potential,” their technological and economic level of development figure in the apportioning of environmental responsibility within the EU.28

A second set of energy considerations surrounds the high, and steadily rising, level of European energy import dependence. Imports account for 50% of EU energy consumption today and are expected to rise to 70% by 2020 in the absence of policies to curtail them. German energy import dependence, at 62%, exceeds the EU average and

27 Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market, OJ L 283 27.10.2001, 39. While each EU member state was required to set national targets for renewable energy, it does not mandate explicit sanctions for those countries that fail to meet their targets.
continues to grow. The Commission notes that renewable energy sources make an “unacceptably modest contribution to the Community’s energy balance,” since indigenous energy resources have a growing geopolitical importance to the EU. Russia’s recent proposal to form a natural gas cartel and its de facto market power in European gas markets intensifies the EU’s geopolitical exposure from import dependence.

The Commission also has noted that the development of renewable energy can be a valuable instrument for economic development and greater social cohesion within the EU. Since renewable energy technologies are developed and manufactured in several EU countries, renewable energy growth, in the Commission’s estimation, can foster job creation, technical capacity development, and international research collaboration across Europe. The German government regards its leading technological position in several renewable energy technology fields as presenting major economic opportunities within Europe, especially in the light of the Commission’s encouragement to EU member states to increase the share of domestic, renewable resources in the energy supply mix, for environmental and security reasons.

3.2 Developments in Domestic Politics and Policy

Environmentalism emerged as a fringe social movement in the 1960s and early 1970s and grew to become a major force in mainstream German politics by the mid-1980s, after local environmental groups joined forces to create a national Green Party. The Green Party emerged at a time of growing disillusionment with Germany’s three major mainstream parties (SPD, CDU/CSU, and LDP), which accounted for all but 1% of the electorate in the mid-1970s. Major environmental issues such as the destruction of Germany’s forest as a result of acid rain and chemical spills in the Rhine River in the 1970s served as high-profile rallying points for the Green cause, as did the Chernobyl disaster of 1986. The emergence of the Green Party as a credible alternative to the traditional parties allowed it to play a major role in forcing environmental issues onto the domestic political agenda throughout the 1980s and 1990s. In 1998, the Green Party reached a new apex of support, winning sufficient votes to participate in five state-level governments and in a ruling national coalition with the Social Democratic Party. 

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durability of this “Red-Green” coalition, which still holds office, testifies to the enduring importance and centrality of environmental issues in the consciousness of the German polity. Green Party representatives in the German Parliament have been strong advocates and sponsors of legislation promoting environmental protection, energy conservation, and renewable energy development. Among the initiatives promoted by Green Party politicians are major pieces of renewable energy legislation such as the StrEG and EEG, and the 100,000 Solar Roofs Program.\footnote{Christopher S. Allen (ed.), \textit{Transformation of the German Political Party System: Institutional Crisis or Democratic Renewal} (New York: Berghahn Books, 1999), 133.}

Two issues in particular highlight the importance of environmental politics in Germany and their close relationship with developments in energy policy. The first issue is the phaseout of nuclear power. An early energy policy action of the Red-Green government was an initiative for the complete phase out of nuclear power in Germany by 2020.\footnote{See Bundesministerium fuer Wirtschaft und Arbeit, “Ausstieg aus der Kernenergie,” available from http://www.bmwi.de/Navigation/Technologie-und-Energie/Energiepolitik/kernenergie-konsens.html} After years of negotiation in Parliament, legislation mandating the phase-out was adopted in April, 2002. Germany now faces the challenge of replacing one-third of its electricity supply from other sources. Even though Germany’s aging nuclear plants have been granted successive license extensions, these facilities are all slated for decommissioning by 2020. A combination of options including the construction of new renewable energy plants, combined cycle gas turbines, conservation, and power imports are likely to be used to offset nuclear power.

The second issue is greenhouse gas control. The future challenges incumbent in nuclear phase-out are compounded by the ambitious greenhouse gas emissions reductions targets adopted by the German government. As mentioned earlier, Germany has agreed to a 21\% reduction from 1990 levels by 2012 as part of the European Union’s Kyoto Protocol commitment. Under a new EU-sponsored proposal for greenhouse gas emissions reduction in the post-2012 period, Germany may be asked to adopt a 40\% reduction target (from 1990 levels) by 2020.\footnote{European Commission, “Action on Climate Change Post 2012: A Stakeholder Consultation on the EU’s Contribution to Shaping the Future Global Climate Change Regime,” available from http://europa.eu.int/comm/environment/climat/future_action.htm.}

The adoption of ambitious targets and timetables for a nuclear phase-out and for greenhouse gas reduction places tight constraints on Germany’s future energy options. The replacement of nuclear power plants with even the cleanest fossil fuel options, such as natural gas turbines, would result in a net increase in energy related carbon emissions. Thus, Germany is left with two primary energy technology options: energy conservation and efficiency technologies that can reduce energy demand, and renewable energy sources that can alter the profile of energy supply.\footnote{Carbon capture and storage is an emerging technology area that several countries are exploring as a potential means of facilitating continued use of fossil fuels with reduced greenhouse gas emissions. In Germany, however, the environmental uncertainties surrounding carbon sequestration have prompted ethical and technical debates. The German government does not sponsor carbon capture research and it appears that sequestration technologies are not envisioned as contributing to Germany’s efforts to reduce energy-related greenhouse gas emissions.} Both of these options are being
pursued aggressively; the short timelines for nuclear phase-out and emissions reduction necessitates the accelerated deployment of energy efficiency and renewable technologies already commercially available or nearing commercial viability. In the light of these constraints, the adoption of policies spurring the diffusion of renewable technologies in the short- to mid-term becomes an apparent necessity.

4. Challenges to the Future Deployment of Renewable Energy Technology in Germany

Even though renewable energy has grown rapidly in Germany, there are major challenges to its continued expansion. One of the most significant political obstacles, for example is the opposition of the coal industry. Germany’s Social Democratic Party (SPD)—the majority party in the current coalition government—has historically been a stronghold of miners and other organized labor groups that are influential in the SPD today. For example, vigorous debate surrounded a 2003 amendment to the Renewable Energy Law aiming to double renewable energy’s share in the electricity fuel mix to 12.5% by 2010. The amendment passed, despite strong resistance to subsidies for wind power by some SPD officials, as a result of Chancellor Schroeder’s promise to provide an additional 17 billion Euro in federal subsidies to the hard coal industry between 2006 and 2012. These subsidies will extend the operating lifespan of several of Germany’s less competitive coal mines and slow the rate of unemployment among German coal workers. The SPD’s coalition partner, the Green Party, agreed to the higher subsidies in exchange for sharp reductions (from 26 million tonnes to 16 million tones) in German coal production and mine closures over the same period.40

The issue of continuing subsidies to renewable energy suppliers has also been a highly contentious political issue in Germany. Revenues raised by the Renewable Energy Law’s levy on all power consumers have been used, in part to reduce the operating costs of renewable electricity on an ongoing basis, leading to outcries from the fossil fuel industries and some politicians. Under the 2003 amendment, such cross subsidies are to be eliminated, although some revenues will remain available for the market introduction of innovative renewable energy technologies.41 A conflict flared within the Red-Green coalition government over this issue, sparked by the language of an ecotax reform bill adopted in May 2004. After protracted negotiations between the (Green-led) Environment and the (SPD-led) Economic Ministries, policymakers agreed that both large and medium size companies would be exempted from energy taxes used to subsidize renewables-generated electricity. Federal subsidies for wind and solar power have also been under heavy pressure and were reduced in 2003.42

Gas procurement policy—particularly rules applying to long-term supply contracts—also presents a problem for renewable energy development in Germany. Many of the largest long-term supply contracts currently in effect do not expire until 2011 and some expire as late as 2030. Contracts between gas suppliers and power producers are typically “take or pay” arrangements, obligating power companies to purchase specified amounts of gas for the contract’s duration. Consequently, long-term contracts may constrain renewable power providers’ access to the electricity market for years to come.43

While the German public has long supported the development and expansion of renewable energy for environmental protection, growing aesthetic, economic, and political concerns have broadened popular opposition to renewables. Wind turbines have become the focus of intensifying controversy, particularly in northern Germany, where wind deployment has been most rapid (see Figure 3 below). Many communities have complained about the siting procedures for wind installations, arguing that they have been shut out of the process in some cases. Communities situated near wind installations complain about the visual impact of wind turbines on the landscape, the turbines’ constant hum, and the frequent tendency of the spinning blades to kill birds.44

Germany’s major conventional power producers, including RWE, E.On, and Vattenfall have also complained about the EEG mandate to purchase renewable energy at fixed prices. For obvious reasons, conventional power producers object to the government’s favorably discriminatory treatment of renewable energy producers who would otherwise not be capable of competing in the marketplace. German power companies brought their complaint unsuccessfully to the European Court, where they argued that Germany’s EEG provision violates EU legislation regarding government assistance to domestic industries.45

Nonetheless, conventional utilities and energy marketers have learned to profit from EEG mandates. Since wind and solar generators produce power mainly during daylight hours, power marketers usually buy renewable energy during the day at stipulated fixed costs and sell it to consumers at even higher rates, especially during peak daytime periods. Cheaper, conventionally-generated power is purchased in larger quantity at night, when demand and tariffs are significantly lower. In 2003, a German energy industry association estimated annual profits from renewable electricity trading at approximately 25 million Euros.46

43 Bechberger and Reiche, 55.
Despite energy companies’ demonstrated ability to benefit from laws such as the EEG, some energy analysts have pointed out that commercial wind and solar electricity makes little economic sense. Even though continuous technological improvement in renewable energy technologies have reduced the costs of renewable energy significantly over the past two decades, improvements in conventional power generation have likewise reduced the costs of conventional electricity. Thus, renewable power providers pursue a moving performance target. In the absence of government supports and policies, these energy sources are likely to remain less competitive with conventional power for the foreseeable future and may even prove uncompetitive with renewable resources imported from other European countries. Wind power in the United Kingdom, for example, is roughly half the cost of German-generated wind power; thus, the integration of the European power grid could intensify the competitive pressures on Germany’s renewable energy industries.47

5. The Effectiveness of Renewable Energy Policy in Germany

Many analysts proclaim German renewable energy policy an unequivocal success.\(^48\) Observers have reached this conclusion principally on the basis of the German government’s adoption, over the course of a decade, of far-reaching energy and environmental laws and, consequently, the rapid deployment of wind power.

In its assessment of Germany’s renewable energy policy, this paper takes a broader look at the development of the renewable energy portfolio, considering three key dimensions as criteria for success. First, it addresses the familiar question of effectiveness of policy in its influence on the deployment of renewable energy technologies and on greenhouse gas emissions. A principal aim of renewables policy in Germany is the reduction of greenhouse gas emissions through the displacement of fossil energy systems; thus, deployment rates and emissions offsets are related—yet distinct—metrics for success.

A second key criterion is the effect of renewables policy on technological advance. Over time, Germany has increasingly adopted deployment oriented policies for energy technology advance, mainly in response to a host of short-term policy imperatives, such as greenhouse gas emissions reduction commitments, discussed earlier. In some cases, the adoption of deployment policies has entailed a largely implicit tradeoff with funding for energy R&D. For example, funding for wind and solar R&D programs have remained constant or experienced small funding declines, while deployment funding in both areas has increased sharply. While market based policies may be effective in moving existing technologies into the market, technology deployment may occur at the expense of research and development programs. In this regard, such policies have been viewed by some observers as undercutting the foundations of future technological advances. Thus, assessing the effectiveness of renewables on technological advance begs a comparison of technology deployment and R&D policies.

A third criterion addressed here is the effectiveness of policy in promoting German renewable technology exports and economic competitiveness. A long-term goal of German energy and technology policy has been to strengthen Germany’s competitive position through policies that promote innovation and improve opportunities for exports of energy technologies.\(^49\) The extent to which renewable energy policy has contributed to German economic competitiveness is a third success metric considered here.


5.1 Deployment of Renewable Energy Technologies and Greenhouse Gas Emissions

Between 1990 and 2003, renewable energy’s share in Germany’s electric power generation fuel mix grew from less than 3% to almost 9%. Over the same period, net electricity consumption in Germany grew by approximately 5%, while carbon dioxide emissions from electric power production declined by roughly 13%.\(^{50}\)

Several factors contributed to the reduction of carbon and other air emissions (including SO\(_X\) and NO\(_X\), and CO). Among these were the decommissioning of many old, inefficient coal-fired power plants in the former East Germany, and their replacement with more efficient gas turbine units. Similarly, end use efficiency improvements in all economic sectors facilitated a steady reduction in electricity intensity in Germany, even as overall power consumption grew steadily. Yet laws such as the EEG also played a central role in spurring the accelerated deployment of renewable energy systems—particularly wind and biomass technologies. The German government claims that, in 2002 alone, avoided emissions resulting from deployed renewable energy technologies for electric power production were almost 36 million tonnes CO\(_2\) equivalent or 10% of total electricity-related CO\(_2\) emissions.\(^{51}\)

Growth in renewable electricity generating capacity grew exponentially following the adoption of the Renewable Energy Supply Act in December 1990, and even more rapidly following the Renewable Energy Feed Law, which came into force in April 2000. While renewable energy in Germany has grown dramatically over the past decade, the future—particularly that of commercial wind and solar photovoltaic installations—may be less certain. As mentioned earlier, political resistance to wind power is growing in both industrial and consumer constituencies. Conventional fossil-fuel utilities are increasingly resentful of the obligation to purchase renewably-generated power at fixed rates, and are bringing their weight to bear in the German Bundestag. As noted earlier, industry lobbies succeeded in securing a reduction in renewable energy feed tariffs as part of the 2004 Ecotax reform.\(^{52}\)

Germany’s planned elimination of nuclear power from the electricity generating fuel mix presents an additional set of political dilemmas heightening the uncertainties surrounding future renewable energy growth. Should the government proceed with the phase-out of nuclear power—which currently accounts for 13% of primary energy supply—and, at the same time, seek to meet its greenhouse gas emissions reduction commitments, renewable energy technologies could continue to deploy rapidly. Alternatively, the ongoing integration of the European electric power grid, in conjunction with difficulties siting...

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new wind and solar facilities, could make power imports the preferred means of meeting future demand growth.

5.2 Renewables Policy and Technological Advance

Like other European Union countries, Germany has gradually increased the emphasis on renewable energy deployment programs in its energy and technology policy portfolio. Increasingly, governments have shifted their attention from basic and applied research programs since the early 1990s and devoted more resources to deployment incentive programs. While this application-oriented shift in emphasis has resulted in the more rapid growth of renewable energy industries and in the commercial deployment of many existing renewable energy technologies, these gains may be purchased at the expense of longer-term R&D programs. As Table 3 shows below, government expenditures for renewable energy market conditioning and deployment incentives exceeded total government energy R&D expenditures by more than 200% in 2002.


<table>
<thead>
<tr>
<th>Policy</th>
<th>Euros (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEG</td>
<td>1,225</td>
</tr>
<tr>
<td>Market Conditioning for the Promotion of Renewable Energy Use</td>
<td>190</td>
</tr>
<tr>
<td>100,000 Solar Roofs Program</td>
<td>69</td>
</tr>
<tr>
<td>ERP Energy and Environmental Conservation Program</td>
<td>119</td>
</tr>
<tr>
<td>DtA Environment Program</td>
<td>46</td>
</tr>
<tr>
<td>Homeowner Incentives</td>
<td>22</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,671</td>
</tr>
</tbody>
</table>

Recent analyses suggest that the distribution of funding among research, development and deployment activities in Germany varies significantly within the renewable energy technology portfolio. While the evolution of the German approach demonstrates a clear trend toward deployment-based activities, there is little evidence on the implications of this focus on technological advance. Since the advance of renewable energy technologies is a function of many variables, including spillovers from the private sector and from R&D programs.


in other countries, research efforts have not yet established the relative significance of individual factors for technological advance.55

5.3 Renewable Energy Technology Exports

Germany’s renewable energy industries and energy policymakers are working to broaden the world market for German-made renewable energy technologies.56 Since domestic production and deployment of wind and solar systems have grown particularly strongly over the past decade, export markets may offer the best opportunity for continued growth as attractive new sites for wind and solar installations grow scarcer at home.

The renewable energy industry already constitutes an important, burgeoning source of new jobs within Germany. Jobs directly related to renewable energy grew from a few thousand in the early 1990s to an estimated 50,000 by 1998. Between 1998 and 2002, that number more than doubled to approximately 120,000. Nearly half of all jobs in the renewable energy industry are directly related to wind power. Export markets will be particularly important to the longevity of these positions, as the domestic market approaches a saturation level.57

Exports now account for approximately 20% and 10% of wind and solar PV production, respectively, in Germany. According to one recent study, exports of solar energy technologies appear to be slowing, while those for wind technologies and related services are growing rapidly due to Germany’s strong competitive position and an expanding global market. This study estimates Germany’s overall annual renewable energy technology exports at 350 million Euro, or 10% of domestic production. The same study projects a world market share of 4-5% for German renewable technology firms by 2010.58 Germany lags behind other industrialized countries, such as the U.S. and Denmark, as an exporter of renewable technologies.59

While German producers of commercial biomass technologies, biofuels, and fuel cells are also active on world markets, government-sponsored export initiatives have focused principally on wind and solar PV systems. In 2001, for example, German wind turbine producers exported 693 turbines (518 MW)—100% more than in the previous year. While the number of turbines exported grew again in 2002 as shown in Figure 6, strong

growth in domestic demand and production actually reduced the share of exports in that year. While the largest export markets today lie within the EU—Italy, Spain, France, and Poland—producers have their future hopes set on major emerging markets, particularly those in China and Brazil.\(^60\)

**Figure 6. German Wind Turbine Exports (MW), 1995-2002**

To a large extent, however, the growth of renewable energy technology export markets depends on factors that are beyond the control of German policymakers or industry. For example, the EU’s ratification of the Kyoto Protocol provided significant export opportunities to Germany’s renewable technology producers, who were well-positioned to capture a large portion of the European market as soon as Kyoto was adopted. However, the domestic policy environments of target countries beyond the EU are likely to be the major determinants of longer-term export potential.\(^61\)

### 6. Summary and Conclusion

Over the past two decades, Germany’s approach toward renewable energy has shifted from a focus on publicly-financed R&D toward policies promoting application and implementation of new technologies in the market place. As this paper has discussed, this transition has occurred gradually and as a result of a number of domestic and international political developments since the 1980s. EU Directives mandating aggressive renewable energy deployment, pressure from domestic environmental advocates and legislators, the phase-out of nuclear power, and commitments to

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\(^60\) Deutscher Bundestag, “Bericht ueber die Bestandsaufnahme durch die Deutsche Energie-Agentur (dena) ueber den Handlungsbedarf bei der Foerderung des Exportes erneuerbarer Energie-Technologien,” Drucksache 15/1862 (November 2003).

international treaties such as the Kyoto Protocol all have been important factors in the evolution of German energy policy. The ascent of deployment-based policies appears to have occurred implicitly and incrementally, in response to political constraints and limited energy technology options, rather than through conscientious changes in the direction of strategic policy or a belief that demand-increasing policies are fundamental drivers of technological advance.

The energy policy environment that has taken shape in Germany over the past decade as a result of these policy pressures has facilitated the rapid growth of renewably-generated electricity in Germany. Moreover, this growth has created new domestic industries that now employ more than 120,000 people directly and indirectly and has offset increasing amounts of greenhouse gases and other air emissions each year. It will be a major challenge for the German government to sustain the current rate of renewables deployment, considering several factors: resistance to renewables incentives from domestic industry lobbies and community advocacy groups, tensions within the coalition government over subsidies for renewable energy, availability of cheap energy imports with EU energy integration, and the gradual saturation of the German renewable energy market. A key turning point may already have been reached earlier this year, when the government reduced compensation rates to renewable energy providers under pressure from the domestic gas and coal industries. While Germany has taken an aggressive approach to renewable technology deployment since 1990, its momentum is not as strong today as in previous years. Despite its many successes in spurring the growth of renewable energy sources, it is not certain that the German government will be able to meet its ambitious environmental and climate policy commitments at home and abroad without major changes to existing policies.

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