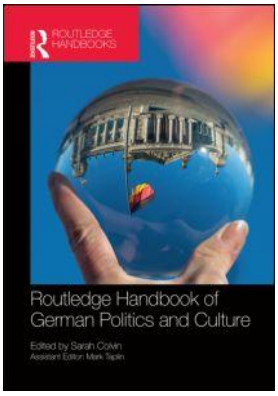

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Climate protection policy

Ecological modernisation, industrial competitiveness, and Europeanisation

Rainer Hillebrand

National pride is a contested concept in Germany. Nonetheless, many Germans are particularly proud of two of their country's achievements: being recognised internationally as an environmental leader, especially in climate protection, and possessing a successful industrial sector that places the country amongst the leading export nations. Both climate protection and the international competitiveness of industry have played a significant role for at least the last two decades in Germany's self-perception and in political debates.

Successive governments since the late 1980s have committed Germany to increasingly strict reduction targets for greenhouse gas emissions (GHGE) in order to help avoid global warming and its adverse consequences such as melting ice caps, rising sea levels, and extreme weather conditions. At present, Germany plans to curb emissions by 40 per cent by 2020 relative to the base year 1990, thereby rendering the country one of the most determined climate protectors in Europe and beyond (Hey 2010: 211). In 2010 the government unilaterally announced a globally unique reduction goal of 80–95 per cent by 2050, envisaged in the so-called 'Energy Concept' (BMWi and BMU 2010). This programme aims to transform the current conventional energy supply system by replacing fossil fuels as the primary energy source with renewables such as wind and solar power.

At the same time as aspiring to environmental leadership, Germany remains one of the most important hubs for manufacturing worldwide. Industrial production is at the core of Germany's economic growth model, which focuses on the export of manufactured goods such as cars, machinery, and chemicals (Hall 2012; Posen 2008). In 2010 exports amounted to 47 per cent of GDP, with comparable industrial countries such as the UK (30 per cent), France (25 per cent), and the USA (12 per cent) relying far less on foreign demand (World Bank 2013). In addition, Germany's industrial sector contributed 28 per cent both to value creation (per cent of GDP) and to employment (per cent of total employment) – a level that is again significantly higher than that of other industrial countries. Germany's focus on export-led growth has important repercussions for business and politics: in order to remain competitive internationally, companies need continuously to innovate and save costs. In the political sphere, debates on proposed measures tend to concentrate on how they are likely to affect industrial competitiveness.

Against this background, Germany has adopted an environmental policy strategy of so-called 'ecological modernisation' (Jänicke 2010; Schreurs 2010; Wurzel 2010). This aims to overcome the apparent trade-off between costly climate protection and economic competitiveness with the help of environmentally friendly technology, which serves a threefold purpose: first, its use reduces the environmental load of economic activities; second, innovative technology improves the quality of goods and/or lowers their production costs, thus strengthening international competitiveness; third, beyond the effects on the polluting sectors, an environmental industry emerges, supplying green equipment domestically and – ideally – abroad.

In this chapter I acknowledge and outline the progress made to date by Germany's version of ecological modernisation. However, I also point to the limitations and practical shortcomings of this approach, which may endanger the achievement of more ambitious reduction goals such as the envisioned 80–95 per cent emission cuts by 2050. While the goal of far-reaching GHGE reductions is more or less uncontroversial in Germany and not questioned here,[1] the (instrumental) path towards a greener economy is subject to contestation. This is true especially of one of the centrepieces of ecological modernisation: the promotion of renewable energy. The German scheme for renewables subsidisation in the electricity sector, as stipulated in the Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz* or EEG), is my case in point. I examine it using an environmental economics framework, looking at the EEG's effectiveness and cost efficiency in reaching the predetermined goals. My argument is that so far the build-up of renewables capacities has proven effective in Germany but that it lacks efficiency, involving unnecessarily high costs with negative consequences for industry as well as for the visionary goal of a complete energy transition. This diagnosis leads me to the question of how those shortcomings can be overcome. I suggest the 'Europeanisation' of ecological modernisation as a way forward, in order to achieve both ecological and economic goals more efficiently.

The first section of the chapter addresses the government's approach to ecological modernisation, including the latest energy transition project, with renewable energy promotion at its core. This policy is then critically assessed from an environmental economics perspective, with an outline of Germany's approach to handling the high costs involved for certain sectors of industry in the face of fierce international competition. The last section looks at opportunities for 'Europeanising' ecological modernisation.

Ecological modernisation and renewable energy promotion in Germany

Germany's climate change policy is rooted in the concept of ecological modernisation (Jänicke 2008). In contrast to approaches that emphasise the negative impact of economic activities on the environment and the limits of economic growth – the Club of Rome, the anti-growth movement, and ecological economics, to name a few (Pearce 2002) – ecological modernisation focuses on the idea that ecological and economic goals are synergetic rather than conflicting, and can be achieved simultaneously through 'green growth' (Seippel 2000; Berger *et al.* 2001; York and Rosa 2003). The key is the contribution of technological progress: green technologies help reduce the environmental impact of economic activities and at the same time tap the economic potential of innovative products and processes. The latter produce cost savings due to the reduced need for resources, resulting in improved international competitiveness. What is more, a completely new environmental industry is likely to develop in order to provide the required environmentally friendly equipment and services. At the macroeconomic level, this new industry pays off in the form of innovative (export) goods, jobs, and tax revenue. In times of increasing fossil fuel prices and stricter climate protection worldwide, the existence of an eco-industry offers huge market opportunities for the home country, thereby (as in Germany) reinforcing the export-led growth model (Hey 2010: 216).

While some innovation is carried out by companies voluntarily in order to seek cost advantages and a competitive edge over others, overall eco-investment falls short of the amount required to achieve ambitious environmental goals. This is because companies feel an incentive to innovate only up to the point where they save cost, for instance the cost of purchasing fossil fuels (private costs). However, environmentally harmful activities also cause so-called external costs by burdening bystanders and/or the environment with pollution. Since these negatively affected third parties (rather than the polluters) have to bear the external costs there is no incentive for the polluters to avoid them. In economic terms, external costs constitute a case of market failure, which renders emission-intensive behaviour artificially inexpensive for individual emitters. As a societal project, ecological modernisation therefore necessitates political action in order to 'coerce' polluters to achieve the higher, socially desirable level of innovation (Jänicke 2008: 558). Green technologies have to be subsidised and/or pollution-intensive behaviour has to be punished by environmental instruments such as eco-taxes, pollution permits or allowances, and eco-standards that transfer the external cost onto the emitters.

In fact, Germany has implemented a mix of environmental instruments to steer businesses and consumers towards greener behaviour (for an overview see OECD 2012). With more than 80 per cent of GHGE in Germany originating from fossil fuels such as mineral oil, gas, hard coal, and lignite (BMWi 2013: 25), one set of measures targets the more efficient use, or even avoidance, of such fuels. Thus, the Red-Green government (SPD and Green party, 1998–2005) introduced an ecological tax between 1999 and 2003 excising the use of non-renewable electricity and fuel. In 2005 Germany in collaboration with its European partners established the EU-based Emissions Trading System (EU-ETS), which requires power plant operators and select industries to operate with cost-causing allowances for every tonne of CO_2 emitted. Both measures tend to make emission-intensive energy sources more expensive and thus their consumption less attractive. In addition, various programmes have been launched to promote a more economic use of energy, encompassing subsidies for combined heat and power generation, residential building insulation, and efficient heating and household appliances.

Besides leaning on the demand side of the energy market, in 1991 Germany started to promote the large-scale build-up of an alternative energy supply system, consisting of renewables such as wind, solar, bioenergy, and geothermal power (Stefes 2010). Since green electricity is still more expensive to generate than conventional electricity, which draws on existing infrastructure and cheap primary energy without being allocated the full external costs involved, renewable technologies are subsidised via so-called 'feed-in tariffs'. Utilities are obliged to provide renewable electricity with priority access to their grids and to remunerate green power generators – including cooperatives, farmers with biogas plants or wind turbines, and home-owners with rooftop solar panels – with feed-in rates fixed in the EEG at above market level for conventional electricity. Conventional power plant operators, in turn, are allowed to cover the difference between the feed-in tariffs they have to pay and the market value of the renewable electricity they receive with the help of an add-on to the electricity retail price: the so-called 'EEG surcharge'. Accordingly, the end-use consumers, rather than the taxpayer, pay for subsidisation.

In principle, the subsidy is fixed per renewable installation (such as a wind turbine or rooftop solar panel) for a period of 20 years following the year of commissioning, with just a few exceptions involving decreased tariffs in later years of the subsidisation period for some renewables such as onshore wind. Otherwise, the feed-in tariffs vary primarily by technology type, installation capacity, and year of commissioning. The first two criteria reflect the actual costs of electricity generation incurred by the respective renewables: for instance, more expensive photovoltaic installations commissioned in 2011 yield feed-in tariffs of between 21 and 28.74 cents/kWh, whereas cheaper onshore wind turbines are subsidised by 8.93 cents/kWh for the first five years upon installation and 4.87 cents/kWh for the remaining 15 years (SVR 2011: 247). The year of commissioning is also crucial – a wind turbine installed in 2000 would have been subsidised more heavily than the same installation in 2010. This degressive tariff design is supposed to mirror cost decreases for equipment over time and incentivise innovation (OECD 2012: 124).

With its approach to ecological modernisation, Germany is praised as a showcase of successful climate protection (Jänicke 2010: 137; Hey 2010). In 2010 GHGE were approximately 24 per cent lower than in 1990 (OECD 2012: 17). The country thereby managed to exceed its commitment to a 21 per cent reduction on average for the period 2008–12, as inscribed in the Kyoto and related EU burden-sharing agreements. What is more, the emission cuts have been fully achieved within the country, without recourse to the Clean Development Mechanism and joint implementation. According to the Kyoto Protocol (adopted in 1997 and in force since 2005), these two flexible mechanisms allow countries to reach part of their abatement obligation abroad in order to minimise the impact on the domestic economy. With respect to its subordinate targets, Germany expanded the share of renewable energy sources in total final energy consumption from 1.9 per cent in 1990 to 12.6 per cent in 2012; in terms of gross electricity consumption, renewables contributed 22.9 per cent in 2012 compared with 3.1 per cent in 1990 (BMU 2013a). Progress has also been made with respect to energy efficiency, the second key pillar besides renewables for a more sustainable energy system. Thus, energy productivity, calculated as GDP per unit of primary energy supply, increased by nearly 50 per cent between 1990 and 2012 (BMU 2013b).

These achievements are even more impressive because the 'greening' has taken place while Germany preserves a substantial industrial base, including the steel, chemicals, and car industries. Admittedly, the collapse of the relatively 'dirty' east German conglomerates and energy generation in the early 1990s helped reduce total German GHGE substantially, as did the global economic downturn in 2008–9. The relocation of parts of industry to eastern Europe and elsewhere further reduced production-based emissions within Germany.[2] Irrespective of these 'windfall gains', climate protection policies, including renewable energy promotion, have contributed significantly to the environmental progress made by turning high- into lower-emission industries (OECD 2012: 9). In addition, a new environmental sector has emerged over the last two decades, consisting to a large extent of the renewable energy industry, which acts as a growth driver and, in 2012, provided approximately 378,000 jobs (BMU 2013a). The development of an environmental goods and services sector maintains Germany's export-led growth model. Having reaped a 'first mover' advantage, the environmental industry is world leading in certain segments and highly active in world markets: it exports approximately a third of its production (OECD 2012: 66). Both environmental and economic achievements in Germany seem to support the ecological modernisation hypothesis that a 'greening' of the economy is possible without the loss of international competitiveness. It is this win-win outcome, in particular, that makes the country a recognised climate policy leader worldwide.

In its 2010 Energy Concept, the German government confirmed, and even extended, its commitment to ecological modernisation. According to this programme, the government aims to create 'radically transformed' and decarbonised energy supply structures, while at the same time allowing 'Germany to remain a competitive industrial base' (BMWi and BMU 2010: 3). As noted above, the overriding environmental target is to cut GHGE by 80–95 per cent from 1990 levels by 2050 (BMWi and BMU 2010). That would make Germany the first industrial nation to achieve the central goal of international climate change mitigation: emission cuts that would limit global average temperature increases to 2°C relative to pre-industrial levels (IPCC 2007). The key drivers of ecological modernisation continue to consist in improved energy efficiency and the expansion of renewable capacities. With respect to the latter, government projections foresee a renewable share of 60 per cent of gross final energy consumption and 80 per cent of gross electricity consumption by mid-century (BMWi and BMU 2010: 5). This would involve an increase by factors of five and four respectively from 2011 levels.

While the goals and key elements of energy transition – significant GHGE cuts without giving up on economic viability, as well as the future role of renewables – are widely accepted across the political spectrum, the feasibility and details of the transformation path are more contested, both in politics and in academia (e.g. SVR 2011; SVU 2011; Monopolkommission 2011; Weber and Hey 2012; Deutsche Bank Research 2013).[3] It is to these criticisms that I now turn. In what follows, the key pillar of the Energy Concept – the massive expansion of renewable energy with the help of feed-in tariffs – is analysed from an environmental economics perspective.

Shortcomings of ecological modernisation: the environmental economics perspective on renewable energy promotion

Besides theorising the cause and nature of and the optimal solution for environmental problems from an economic point of view, environmental economics deals with 'the choice of the means of achieving an environmental goal' (Pearce 2002: 72). At this more practical level, the claim to 'optimality' is abandoned and environmental goals are assumed to be determined in the realm of politics or natural sciences rather than from within the discipline of economics. Consequently, the focus is on the effectiveness and efficiency of environmental instruments in achieving predetermined goals. 'Effectiveness' here refers to the capacity of an instrument to have an impact on economic actors and steer them towards the desired goal (European Commission 2008: 24). Economic efficiency demands that the given environmental objective is reached 'at minimum cost to the economy' (Baumol and Oates 1971: 42). In a dynamic perspective, this implies the existence of incentives for polluters to keep searching for new technologies that, in the future, might allow for even cheaper abatement (Pearce 2002: 73).

In the context of Germany's ecological modernisation, effectiveness and efficiency are important criteria. It is the primary aim of German climate protection policies to be effective: that is, actually to achieve GHGE cuts. That requires instruments that have a negative impact on polluters and a positive one on non-polluters. On the efficiency side, 'least-cost' instruments are sought. The least-cost property of an environmental instrument renders the cost burden on the economy as low as possible, thus doing minimal harm to households and firms. This is particularly important for German companies that compete internationally and therefore are concerned about their production costs. The plea for innovation resonates with the key driver for successful ecological modernisation: green technologies. Environmental economics thus provides a useful framework for examining whether the German approach to energy transition, particularly the renewables support scheme, is conducive to the environmental and economic ends of ecological modernisation. In what follows I look at the effectiveness and efficiency of renewable energy promotion in the electricity sector.

The effectiveness of renewable energy promotion

In comparison with quantity-based support schemes such as the UK Renewables Obligation system, Germany's price-based subsidisation of renewables is widely praised as an effective tool for 'greening' the energy sector (European Commission 2008: 8; OECD 2012: 125). This is true at two levels, in that it supports an increase in green electricity (the subordinate target) and supports GHGE reductions (the primary goal, as stipulated in §1 of the EEG). With the help of feed-in tariffs, Germany has achieved a massive expansion of its renewables capacities. The installed capacities for the two most significant sources – onshore wind and photovoltaics – increased from 0.055 GW in 1990 to 31 GW in 2012 for wind and from 0.0006 to 32.6 GWp[4] for photovoltaics (all data in this paragraph from BMU 2013a). Overall, renewables-based capacity for electricity generation multiplied almost 19 times between 1990 and 2012, from approximately 4 to 76 GW. That expansion of capacity is reflected in the rise of green electricity: while renewables contributed 3.1 per cent to gross electricity consumption in 1990, the share rose to 22.9 per cent in 2012. With respect to the primary goal, renewable energy sources led to an abatement of 145.5 million tonnes, equivalent to 15.6 per cent of all GHGE in Germany in 2012. More specifically, the EEG, which promotes green electricity but not green heat and fuel consumption, saved approximately 81 million tonnes of GHGE through the provision of green electricity.[5]

Renewable energy has the advantage of not being subject to the so-called 'rebound effect', which is one of the weak points of other climate protection instruments such as the promotion of energy efficiency. The problem occurs when the instrument triggers incremental innovation so that the emission intensity of an economic activity is reduced rather than driven down to zero as in the case of a radically new technology. For instance, a power plant with improved technology but still based on fossil fuels might have lower GHGE per unit of electricity generated. However, this improvement does not guarantee an absolute GHGE reduction. Indeed, the emission load is even likely to rise if electricity output grows substantially over time, overcompensating for the per unit abatement formerly achieved. In contrast, renewable energy constitutes a radically different technology from conventional electricity generation. Except for the emissions during the production of renewables equipment (Deutscher Bundestag 2007: 14), renewable installations are GHGE-free throughout operation, regardless of the amount of electricity produced over time, thereby rendering their contribution to climate protection permanent.

Despite this in-principle advantage, the ecological effectiveness of renewable energy is in doubt when one looks at the concrete instrumental mix implemented in Europe. Since the introduction of the EU-ETS in 2005, all utilities are required to work with so-called 'allowances' for the units of CO_2 and some other GHGE they emit. When green electricity is fed in, the level of the allowances required by German utilities shrinks, and power plant operators can sell them off to other emitters EU-wide. While emissions might therefore go down in Germany due to the use of renewables, GHGE will rise elsewhere in the EU, thus neutralising any mitigating effect on global warming. This is true not least because the amount of renewable electricity in Germany has risen unexpectedly, most significantly in the area of photovoltaics, where the government systematically underestimated capacity build-up (SVR 2012: 274).[6] Accordingly, it was impossible in advance to factor in fully the contribution of German renewable capacities when the total EU-wide 'cap' was fixed for GHGE traded under the EU-ETS.[7] In other words, the reduction in GHGE units due to an unanticipated use of renewables brings no additional abatement benefit. In this sense, the effectiveness of renewables promotion in Germany can be felt only when their potential contribution to GHGE reductions is reflected in a lower EU-ETS cap.

The economic efficiency of renewable energy promotion

Besides ecological effectiveness, the question arises as to whether the German promotion scheme for renewable energy sources is an economically efficient instrument to the extent that it achieves GHGE reductions (primary goal) and the expansion of renewable capacities (subordinate goal) at the lowest cost possible.

With respect to the goal of mitigating climate change, the economic efficiency of renewables promotion can be assessed by looking at so-called (marginal) abatement costs, defined as the cost of reducing GHGE by an additional unit (Hanley *et al.* 2013: 288). Renewables promotion is the efficient option if there is presently no cheaper way available to cut GHGE from its status quo level, that is, if marginal abatement costs are minimal. However, even though marginal abatement costs are a basic theoretical concept, their calculation is difficult in reality and the results are somewhat ambiguous. This is due to the huge number and complexity of assumptions required regarding, for instance, the technology displaced (e.g. gas or coal), the site of the renewables, and the various cost categories considered (Marcantonini and Ellerman 2013; Torvanger and Meadowcroft 2011). Nevertheless, and sufficient for the argument made here, there is widespread consensus that current renewable technologies imply relatively high abatement costs, well above the level of the benchmark EU-ETS carbon price (e.g. OECD 2012: 126; Helm 2012: 76). For instance, with respect to the German renewables promotion scheme, Marcantonini and Ellerman (2013: 20) estimate the abatement costs of onshore wind technology at €43/tCO_2 on average for the years 2006–10, while the equivalent for photovoltaics was €537/tCO_2. Frondel *et al.* (2010: 4052–3) calculate abatement costs of €54/tCO_2 for onshore wind and €716/tCO_2 for solar power from photovoltaics, whereas the International Energy Agency (IEA) projects costs of €1,000/tCO_2 for the latter (IEA 2007: 40).

In contrast, the carbon price in the EU-ETS has not passed the threshold of €30/tCO_2 since its inception in 2005 (SVR 2011: 24), although admittedly the low price level is mainly due to an over-generous supply of allowances. Nevertheless, rather than employing subsidised renewable technologies, abatement would currently be achieved more cost-effectively if undertaken via the EU-ETS (Frondel *et al.* 2010: 4053). And further options are available: for instance, according to the IEA even the more cost-intensive building insulation projects in Germany amount to €20–30/tCO_2 abated, 'making these policies 30 to 50 times less expensive than the feed-in tariffs for solar PV' (IEA 2007: 74). Given that the geographical location of GHGE does not matter for global warming, it would be even more advantageous to realise cheap abatement abroad, an issue that has been considered far too little in Germany, with its national focus on ecological modernisation. For instance, Helm suggests that the substitution of coal by less emission-intensive gas in power plants is currently the most pressing climate protection measure, in the light of the 'dash-for-coal' (2012: 195) worldwide. In particular, it would positively impact on the costs of climate change mitigation if the scheduled build-up of power stations with a capacity of 1,000 GW in China and India by 2030 was based on natural or shale gas rather than dirty coal as planned (Helm 2012: 195).[8] Abatement might, therefore, take place outside Germany, although this does not mean that the country is freed from its obligation to invest in climate protection, for instance in the form of large-scale research and development (R&D).

Given the variation in costs of currently available GHGE abatement options, the build-up of renewable capacities in Germany – especially photovoltaics – seems an excessively costly way of achieving climate protection, while 'existing low-cost abatement options have not been sufficiently exploited' (OECD 2012: 119). The renewables support scheme might still be justifiable when considering alternative goals such as the expansion of green energy in an economy's energy mix (the subordinate goal). Instead of being an instrument for short-term GHGE reduction, the share of renewables becomes a target in itself. This could be reasonable if one thinks more strategically and in the long term. Renewables might yet be the cheapest abatement option in the future, when all alternatives have been fully exploited but ambitious reduction goals have still not been achieved. Leaving aside climate protection, renewables can be worthy of subsidisation from an industrial policy point of view as they involve innovative technologies with huge potential for exports and job creation. In energy security terms, renewable energy sources such as wind and solar power are available in Germany, and therefore render the country less import dependent on fossil fuels. Assuming that there will be rising global demand for fossil fuels, with an upward impact on the oil price and on the continued technological progress of renewables, green energy might eventually become the cheapest primary energy source, so that the current subsidisation equals an investment with high expected returns in the future (German Advisory Council on Global Change 2011: 4). However, a price hike for fossil fuels cannot be taken for granted. The USA, for instance, has just started exploiting shale gas, which seems abundant and fairly cheap.

In a nutshell, the promotion of renewables capacities would be an investment in an environmentally friendly, secure, and affordable energy system, with additional benefits for climate protection; the direct impact on current GHGE would be of less concern. In fact, all the above reasons have been put forward in Germany as justifications for the renewables promotion scheme, for instance in the debates surrounding the frequent amendments to the EEG or the Energy Concept (e.g. BMU and BMWi 2010; SVR 2012).

The question of economic efficiency thus arises anew with respect to the subordinate target of 'greening' the energy system, whereby the least-cost subsidisation scheme constitutes the most efficient instrument. This is difficult to assess empirically because Germany has retained largely the same system of feed-in tariffs since 1991 and no alternative promotion scheme such as a quantity-based quota[9] has been tried or tested. From an economic point of view, the German system reveals some inefficiency due to the technology-specific nature of feed-in tariffs, which mirror the state-of-the-art of the respective technologies. This means that less competitive solar power from photovoltaics is remunerated more highly than low-cost onshore wind (OECD 2012: 87). Accordingly, subsidies spent on solar power lead to a lesser expansion of the renewables share than the same amount spent on onshore wind. A shift of subsidies would therefore make the German scheme more efficient, resulting in a higher share of green electricity with unaltered, or possibly even lower, feed-in tariffs.[10]

The inefficiency of the feed-in tariff scheme, which has been at the centre of public debates in Germany and beyond (Böhringer 2010), is reflected in the sharp increase in the EEG surcharge imposed on residential electricity consumers. Thus, the apportionment of cost for green electricity rose from 0.2 cents/kWh in 2000 to 5.28 cents/kWh in 2013, resulting in an increase in electricity prices for end-consumers. The key cost driver is photovoltaics: between 2009 and 2011 alone, the installed capacity of solar panels grew by approximately 12 GW. The commissioning during just these three years gives an estimated net cost of €60.7 billion (2011 prices), accumulating until 2031, when the 20-year subsidisation period will have run out (Frondel *et al.* 2013: 31). At the same time, solar electricity from photovoltaics has been of relatively low salience in renewable electricity generation. It contributed only 15.6 per cent of gross electricity consumption from renewables in 2011, with much lower shares in former years; in contrast, more efficient onshore wind supplied 39.1 per cent (BMU 2013a: 12).

The economic inefficiency of the current photovoltaics boom is due to various trends. While the feed-in tariffs, including guaranteed priority access to the grid and fixed prices for 20 years, have a low degression rate with respect to newly commissioned installations in subsequent calendar years, the price of solar panels has decreased sharply since 2007, when China entered the market as a major supplier of photovoltaics equipment. Accordingly, investment in solar panels has become ever more lucrative and peaked in 2012, amounting to €11.2 billion, approximately three times the amount invested in the second most used technology, wind power (BMU 2013a: 37). Eventually, politics had to react to this unanticipated 'investment boom-cum-EEG surcharge explosion' by scaling down the feed-in tariffs for newly commissioned solar panels in a series of amendments to the EEG. While the cost of photovoltaics promotion seems to be under control, despite the ongoing payment obligation for 20 years, biomass and offshore wind energy constitute two additional heavily subsidised but relatively expensive technologies (SVR 2012: 283).

Despite the high growth rate in green electricity generation, especially during the last decade, renewables at present still have a relatively small share in the German energy mix, so the inefficiency problem remains confined. However, this is about to change with the energy transition project. Accordingly, a huge and still unquantifiable rise in cost is to be expected, including additional investment, which is necessary when renewables represent the prime energy source rather than a niche one.

First, the existing electricity network has to be upgraded and attuned to the needs of the generation of green electricity, requiring an expansion of 3,450 km by 2020 (SVR 2011: 228). The conventional electricity system involves a one-directional current flow from the power plant to the consumer, with the electricity generators being located in close proximity to their customers. In contrast, a green energy system consists of a huge number of decentralised small-scale generators, who are, to a large extent, simultaneously consumers, for example, homeowners with rooftop solar panels. Other kinds of renewable energy (onshore and offshore wind) are generated primarily in northern and eastern Germany, where meteorological conditions are more favourable, whereas electricity demand is higher in the south due to the spatial distribution of industry.

Second, because the production of green electricity depends on weather conditions, the amount it is possible to generate at a given time may not be sufficient (or too big) to meet demand. In order to secure electricity supply and grid stability at any time, additional investment is necessary. This can take the form of new flexible coal and gas-fired power stations that can be easily hooked up if there are adverse weather conditions. Storage capacities are needed to even out intermittent demand and supply fluctuations, including pumped-storage power plants, biomass/biogas plants, and batteries for electric vehicles.

Besides being the low-cost option in a given situation, an economically efficient instrument will incentivise polluters to engage continuously in innovation, searching for new and increasingly inexpensive abatement options. While the need for political intervention to trigger innovation is undeniable from an economic standpoint, the German renewables promotion scheme shows deficiencies in that respect (SVR 2012: 280–1). The feed-in tariffs aim to accelerate market penetration for already existing, relatively expensive technologies in early stages of diffusion, thereby realising learning curve effects (OECD 2012: 87). This should eventually render them competitive compared with established conventional technologies, so that in the long term renewables become marketable without subsidisation. In addition, by exploiting economies of scale in the domestic market, renewable technologies potentially acquire a 'first-mover' advantage internationally, with huge business potential in a globally dynamic market.

The stability of the system, including the fixing of tariffs for 20 years, the priority access to the grid, and the independence from public budgets due to the cost apportionment to electricity consumers rather than to taxpayers all provide a protected niche in which investment can thrive. However, this guaranteed return on investment, without price or commercialisation risk, is diverting investment from yet unknown, probably more efficient, renewable technologies. With the help of technology-specific feed-in tariffs, the government 'picks winners' without knowing whether those technologies will prove to be superior and cost efficient in the longer term. In contrast, 'technology-open' R&D programmes are relatively insignificant in Germany in comparison with the amount of funding available under the EEG. Thus, potential future cost reductions for a green energy system might be missed, since the technological status quo is subsidised rather than R&D for new developments such as 'storage and batteries, the electrification of transport, and new electricity-generation technologies' (Helm 2012: 215).

To sum up, Germany's cornerstone policy of energy transition and climate protection – that is, the promotion of renewables – has proven very effective in building green electricity capacities, although less effective in terms of GHGE reductions because of the overlap with the EU-ETS. However, with its technology-specific feed-in tariffs the approach seems overly expensive and thus not economically efficient with respect to either climate protection or the greening of the energy system. This also holds true in a dynamic perspective, concerning the incentives for invention. The high cost places an unnecessary burden on energy consumers, both households and industry. I turn now to the issue of how they have reacted to this cost burden.

Impact on the economy and industrial competitiveness

While households find it relatively hard to evade the cost burden,[11] industry has various options for dealing with it. For one, it can invest in integrated green production technologies that require less electricity input. This is exactly in line with the ideas of ecological modernisation, in that expensive energy triggers innovation that is conducive to both the environment and industrial competitiveness. However, if ecological modernisation is technically impossible or economically unviable, energy-intensive industry has at least two further options, both of which impede ecological modernisation. First, it can relocate energy-intensive parts of its value-added chain abroad, for instance to so-called pollution havens where environmental policy costs are less perceptible. One result of this relocation is the so-called 'carbon leakage' effect: a displacement rather than a reduction of GHGE on a global scale. Moreover, jobs and tax revenue are lost in Germany if companies leave or downsize (Hillebrand 2013: 669). Second, industry can lobby government for exemptions from the instrumental burden – a strategy that is particularly promising for sectors that provide many jobs, and have well-established links with politics and the potential to threaten with relocation. Again, the goals of ecological modernisation are compromised, since the price signal is removed and a greening of industry does not materialise.

In Germany, the 'losers' of ecological modernisation (such as the chemicals, paper, and other energy-intensive industries) have in fact been granted special arrangements. For instance, feed-in tariffs are reduced to less than 10 per cent of the normal EEG surcharge for companies with an electricity consumption of more than 1 GW per year and electricity costs surmounting 14 per cent of their gross value added. For 2014, 2,367 companies applied for the surcharge rebate, significantly more than in former years (Balser 2013). If the rebate is granted, companies are relieved of approximately €5 billion of their electricity costs, which then have to be apportioned to households and other non-exempted businesses. Similar exemptions apply for other climate protection instruments. The eco-tax provides tax relief for energy-intensive industries such as chemicals and steel amounting to approximately €2.3 billion per year (Grossarth 2012). German governments have also intervened time and again in the EU decision-making process on behalf of the car industry, in order to achieve more lenient CO_2 standards for fuel-consuming German luxury brands (Hey 2010). And the German government has used its influence in Brussels to get generous allocations of emission allowances in successive trading periods of the EU-ETS (Schreurs 2010). While this handling of costs might help industry in terms of securing (international) competitiveness, it erodes ecological modernisation as it 'limits the scope and effects of environmental policy' (Jänicke 2008: 564). The scale of the already existing exemptions is noteworthy relative to the magnitude that is to be expected in the case of a complete transformation of the energy system (at present the ecological modernisation project in Germany is still in its infancy). In fact, recent debates about the energy transition project have focused on cost issues rather than on its ecological and economic potential (Gawel and Hansjürgens 2013: 284), and both government and opposition have discussed ways of making policies more efficient. One solution might lie in the 'Europeanisation' of ecological modernisation.

The need for Europeanisation

Germany is one of the most ambitious countries in the world when it comes to climate protection. With its unilateral energy transformation project, the government underlined its claim to international environmental leadership, with positive effects expected for the environment as well as for industry. However, the overlap of instruments in Europe and the scope of investment required for a renewables-based energy system mean that nationally confined ecological modernisation has been stretched to its limits in terms of effectiveness and economic efficiency. For energy transition to be a viable option, an international dimension is now necessary (BMWi and BMU 2010; Häder 2010; SVR 2011). This is true for several reasons.

As far as the ecological goal is concerned, the German share of 2.4 per cent of worldwide GHGE in 2009 is relatively insignificant, with China (25.6 per cent) and the USA (17.6 per cent) at the top (my calculations, based on data from World Bank 2013). Accordingly, Germany's emission cuts may provide evidence that climate protection is feasible in an industrialised country and may exert moral pressure on others to join in, but this is a far cry from sufficing to mitigate global warming. Without international commitment, the public good of climate change mitigation cannot be achieved.

With respect to the cost of ecological modernisation, renewable energy could be generated more cheaply if installations were located in sites with ideal topography and climate conditions, irrespective of territorial boundaries. Photovoltaics, for example, can be maintained more efficiently in sun-rich areas of southern Europe or the Maghreb than in Germany. Wind turbines generate cheaper energy in high-wind regions. Intermittency problems as a result of naturally fluctuating wind and solar supplies could be more easily evened out if more diverse sites were included. Topography in countries such as Norway or Switzerland would allow for inexpensive load balancing, thanks to cheap pumped-storage capacities and hydroelectricity.

In addition, industry would suffer less from high energy costs if competitors were subject to a comparable policy regime. Assuming a level playing field, exemptions from eco-standards, taxes, and surcharges would be unjustifiable. In fact, energy-intensive industries in Germany and beyond would have to bear the cost increases similarly and – if investment in green processes proved technologically impossible – suffer from a price-induced downturn in demand, leading to a downsizing of dirty industries worldwide, rather than displacement in the form of carbon leakage. At the same time, Germany's environmental goods and services sector would benefit from a rise in demand for green technologies if legislators abroad kept a tighter rein on emissions (Hillebrand 2004). With 'de-growth' taking place in resource-intensive industries and cleaner production on the rise, globally effective green growth would occur (Jänicke 2012: 98).

While it seems clear that ecological modernisation in general and energy transition in particular require international backing, the question arises how this can be achieved. So far Germany has been a strong supporter of the global Kyoto/post-Kyoto processes as the first-best solution, with the EU taking the lead in negotiations. Those processes involve internationally agreed GHGE reduction goals that are broken down into national or regional obligations and enforced with the help of nationally implemented instruments. Germany pressed ahead in 1997 by accepting a 21 per cent reduction target for 2008–12 under the EU burden-sharing agreement that enforced the Kyoto Protocol. With respect to the (still ongoing) post-Kyoto negotiations, Germany pushed the EU during its 2007 presidency to offer a 30 per cent GHGE cut, provided that other emitters reduce their emissions by 20 per cent. However, given past experiences and other emitters' apparent lack of interest in committing to change, it is questionable whether a meaningful global agreement can be reached any time soon (Feld *et al.* 2011; Helm 2012).

Even though, in principle, climate protection remains a global challenge requiring a global effort, nations may have to look for alternative solutions, and regional cooperation in Europe might provide 'a practical first step' (Prat 2010: 34). Both the effectiveness and the efficiency of energy transition would benefit if the project were more deeply embedded in the European context – in contrast to the predominantly national design of energy policies in EU member states that we see today. Attuning instruments with goals on a European scale would avoid the distorting effects of an overlap of instruments (such as the overlap between the German EEG and the EU-ETS). The latter – or, alternatively, a carbon tax – could target the primary goal of GHGE cuts, while renewables and their future development could be promoted as a strategic, long-term option. Ambitious goals for the use of green energy – such as the EU's goal of a 20 per cent share of renewables in gross final energy consumption by 2020 – could be achieved more easily if advantage were taken of local conditions EU-wide for wind and solar power (Weber and Hey 2012: 50). The physical and regulatory integration of the EU energy market beyond its still fractured state would help exploit regional advantages and balance out intermittency problems. From an economic perspective, the Europeanisation of ecological modernisation would lead to greater efficiency in achieving environmental goals, involving lower costs overall.

Conclusion

With respect to climate policies, Germany is currently characterised by a high degree of conformity. Most Germans perceive global warming as a major threat to humanity and climate protection as a key policy goal. For more than two decades, all major political parties have agreed on the need to cut down on GHGE and to engage internationally for a global climate agreement. With energy consumption providing the most important source of GHGE in Germany, consensus also extends to the instrumental level – at least after the dispute concerning the role of nuclear energy was settled in 2011 following the nuclear fallout in Japan. Government and opposition parties agree on the need for ecological modernisation, with the transformation of the energy system towards renewables at its core. The energy transition project coincides with the economic tier of ecological modernisation in that it triggers energy savings and leads to the emergence of a modern environmental industry. In the German context this is particularly desirable, since the country's economy relies heavily on the export of manufactured goods, with green products adding new business potential.

Despite some caveats, ecological modernisation has been a success in Germany to date, in that it has helped increase the share of green energy while at the same time safeguarding industrial competitiveness and the development of a new environmental industry. However, the devil is in the detail. From an environmental economics perspective, the key instrument – renewable energy promotion with feed-in tariffs – has severe shortcomings that make the energy transformation project more expensive than is necessary. This is a particular problem for Germany, a still heavily industrialised country preoccupied with competitiveness concerns.

Because a matching commitment from other polluting nations and thus an international level playing field is lacking, the cost burden environmental instruments bring has generated political opposition from German industry as the 'loser' in ecological modernisation. Thus, some energy-intensive industries have managed to achieve exemptions from the eco-tax as well as from the feed-in tariffs cost apportionment, at the expense of households and other unprivileged sectors. This hollows out the ecological modernisation project and bodes ill for the more substantial transformation of the whole energy system by 2050.

A way forward in Germany's pursuit of 'ecological modernisation in international competition' can be found in further internationalisation and Europeanisation. If the country expands its agenda to the EU level and beyond, ecological modernisation will become more effective in climate protection terms. In addition, the costs of renewables could be reduced substantially and a level playing field for industry would become more likely. The key to Germany's success in ecological modernisation, therefore, lies in the export of this very model.

Notes

1 For another opinion see, for example, Feld *et al.* (2011), who question the viability of climate change mitigation with the help of ambitious GHGE cuts, especially if undertaken unilaterally. Rather, they suggest that adaptation measures to global warming be considered.

2 The relocation of industry reduces Germany's production-based GHGE, but the fact that goods produced abroad are (re-)imported and consumed domestically makes Germany's (consumption-based) emission load rise. However, for Germany the difference between consumption- and production-based counts is relatively low due to the country's excellent export performance (OECD 2012: 115).

3 Another long-standing issue in German energy policy regarding nuclear energy was resolved in 2011 (Jahn and Korolczuk 2012). While in the initial version of the Energy Concept the conservative-liberal government (2009–13) assigned an important role to nuclear power as a so-called 'bridge technology' to the age of renewables – a proposal heavily contested by the opposition parties – the nuclear disaster of Fukushima in March 2011 'forced' government to make a sharp U-turn. Thus, Chancellor Merkel announced the end of nuclear power in Germany by 2022, a near-restoration of the initial phase-out plan agreed in 2000 by the then Red-Green government and major utilities. With the legal enactment of the phase-out plan by an overwhelming majority in the German Bundestag in June 2011, the end of nuclear power in Germany is all but sealed.

4 The symbol GWp stands for gigawatt-peak, which is regularly used to signify the nominal power of photovoltaics installations. The nominal power is the power generated by photovoltaic panels under certain standard conditions such as when the temperature of the cells is 25°C and the light intensity amounts to $1000 W/m^2$.

5 Besides green electricity, government promotes the use of biofuels and heat from renewables with a separate set of instruments, including tax exemptions for biofuels and the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG). However, the promotion of green electricity via the EEG has so far been the most important and effective policy tool.

6 While government expected an additional accumulation of 0.6 GW in photovoltaic installations in 2008, the actual increase amounted to more than 2.9 GW. In the following years, this trend exploded, showing an annual growth in installed capacity of 3.8 (2009), 7.3 (2010), and 7.5 GW (2011) (SVR 2012: 274).

7 Some scholars argue that the contribution of renewables towards GHGE reduction has been factored into the amount of ETS allowances issued and that the EEG is required as an instrument to reduce CO_2 emissions despite the existence of the EU-ETS (e.g. Weber and Hey 2012).

8 In this context, the large-scale exploitation of shale gas in the USA, and prospectively in China, might be a positive development for climate protection, though possibly not for other environmental concerns such as the use of water and chemicals. However, as Helm (2012: 195–212) outlines, gas is still a carbon fuel and therefore might act only as a transitional option until carbon-free technologies are cheaply available.

9 In a quota system, a market for certificates for green electricity is established. On the demand side, utilities are obligated to source a certain amount of electricity from renewables. In order to fulfil this

obligation they have to obtain green certificates and hand them in to the government at the end of a trading period (e.g. a year). On the supply side, renewable electricity producers offer these green certificates which they receive from government or another institution for the amount of green electricity generated. Renewable electricity producers thus do not receive a fixed feed-in tariff but a varying price from utilities, depending on supply and demand for green certificates (SVR 2011: 256–9).

10 Alternative views exist. For instance, the European Commission in its 2008 report on renewables subsidisation in the EU comes to the conclusion that 'well-adapted feed in tariff regimes are generally the most efficient and effective support schemes for promoting renewable electricity' (European Commission 2008: 3). The report states that the German approach is one of the most successful with respect to onshore wind and photovoltaic energy, amongst other things.

11 Households can invest in more energy-efficient household appliances and better insulation as well as in their own rooftop photovoltaics, benefiting from the renewables boom. However, this strategy is confined to homeowners, which means that the renewables promotion scheme acts regressively and redistributes costs from homeowners and big industry to non-homeowning electricity consumers and SMEs (Helm 2012: 89). In addition, households tend to have less influence in the political process.

Bibliography

Balser, M. (2013) 'Immer mehr Konzerne fordern Strompreis-Rabatte', *Süddeutsche Zeitung*, 12 July. Online. Available at www.sueddeutsche.de/wirtschaft/oekostrom-umlage-immer-mehr-konzerne-fordern-strompreis-rabatte-1.1719644 (accessed 21 July 2013).

Baumol, W.J. and Oates, W.E. (1971) 'The use of standards and prices for protection of the environment', *The Swedish Journal of Economics*, 73(1): 42–54.

Berger, G., Flynn, A., Hines, F., and Johns, R. (2001) 'Ecological modernization as a basis for environmental policy: Current environmental discourse and policy and the implications on environmental supply chain management', *Innovation,* 14(1): 55–72.

BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) (2013a) *Development of Renewable Energy Sources in Germany 2012*, February 2013 version. Online. Available at www.erneuerbare-energien.de/fileadmin/Daten_EE/Dokumente__PDFs_/20130328_hgp_e_ppt_2012_fin_bf.pdf (accessed 9 July 2013).

BMU (2013b) 'Energieproduktivität und Wirtschaftswachstum'. Online. Available at www.bmu.de/fileadmin/bmu-import/files/bilder/allgemein/image/jpeg/grafik_energieeffizienz.jpg (accessed 8 July 2013).

BMWi (Federal Ministry of Economics and Technology) (2013) 'Energiedaten: ausgewählte Grafiken'. Online. Available at www.bmwi.de/BMWi/Redaktion/PDF/E/energiedaten-ausgewaehlte-grafiken,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed 10 July 2013).

BMWi and BMU (2010) *Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply*. Online. Available at www.bmu.de/files/english/pdf/application/pdf/energiekonzept_bundesregierung_en.pdf (accessed 29 September 2011).

Böhringer, C. (2010) '1990 bis 2010: Eine Bestandsaufnahme von zwei Jahrzehnten europäischer Klimapolitik', *Perspektiven der Wirtschaftspolitik*, 11(s1): 56–74.

Deutsche Bank Research (2013) 'Energy turnaround: Uncommon similarities, but significant differences in the detail', *German Policy Watch*, 24 June. Online. Available at www.dbresearch.de/PROD/DBR_INTERNET_EN-PROD/PROD0000000000315772.pdf;jsessionid=62C127B1B07CD23B2C3D65B3E69B9B41.srv-net-dbr-de (accessed 5 July 2013).

Deutscher Bundestag (2007) *CO2-Bilanzen verschiedener Energieträger im Vergleich: Zur Klimafreundlichkeit von fossilen Energien, Kernenergie und erneuerbaren Energien*, Info-Brief WD 8–056/2007, Wissenschaftliche Dienste, Berlin: Deutscher Bundestag.

European Commission (2008) *The support of electricity from renewable energy sources*, Commission Staff Working Document, SEC(2008) 57, Brussels: Commission of the European Communities.

Feld, L.P., Konrad, K.A., and Thum, M. (2011) 'Umdenken in der Klimapolitik nach dem Gipfel von Cancun!' *ifo schnelldienst*, 64(5): 8–11.

Frondel, M., Ritter, N., Schmidt, C.M., and Vance, C. (2010) 'Economic impacts form the promotion of renewable energy technologies: the German experience', *Energy Policy*, 38: 4048–56.

Frondel, M., Schmidt, C.M., and Aus dem Moore, N. (2013) 'Marktwirtschaftliche Energiewende: Ein Wettbewerbsrahmen für die Stromversorgung mit alternativen Technologien', *Zeitschrift für Energiewirtschaft*, 37: 27–41.

Gawel, E. and Hansjürgens, B. (2013) 'Projekt "Energiewende": Schneckentempo und Zickzackkurs statt klarer Konzepte für die Systemtransformation?', *Wirtschaftsdienst*, 93(5): 283–8.

German Advisory Council on Global Change (2011) *Transforming Energy Systems*. Online. Available at www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/factsheets/fs2011-fs2/WBGU_FS2_2011_Energie_en.pdf (accessed 25 October 2011).

Grossarth, J. (2012) 'Bundesregierung verlängert Ausnahmen bei der Ökosteuer', *Frankfurter Allgemeine Zeitung*, 1 August. Online. Available at www.faz.net/aktuell/wirtschaft/wirtschaftspolitik/oekosteuer-ausnahmen-fuer-energieintensive-unternehmen-verlaengert-11840604.html (accessed 11 July 2013).

Häder, M. (2010) 'Das Energiekonzept der Bundesregierung – Darstellung und ökonomische Bewertung', *Orientierungen zur Wirtschafts- und Gesellschaftspolitik*, 126: 36–42.

Hall, P. (2012) 'The economics and politics of the euro crisis', *German Politics*, 21(4): 355–71.

Hanley, N., Shogren, J., and White, B. (2013) *Introduction to Environmental Economics*, 2nd edn, Oxford: Oxford University Press.

Helm, D. (2012) *The Carbon Crunch: How We're Getting Climate Change Wrong – And How to Fix It*, New Haven: Yale University Press.

Hey, C. (2010) 'The green paradox: climate leader and green car laggard', in S. Oberthür and M. Paellemaerts (eds) *The New Climate Policies of the European Union: Internal Legislation and Climate Diplomacy*, Brussels: Brussels University Press, 211–30.

Hillebrand, R. (2004) *Rationale Umweltpolitik und Globalisierung der Wirtschaftsbeziehungen: eine Analyse ausgewählter Umweltpolitikansätze*, Frankfurt a.m.: Peter Lang.

Hillebrand, R. (2013) 'Climate protection, energy security and Germany's policy of ecological modernisation', *Environmental Politics*, 22(4): 664–82.

IEA (International Energy Agency) (2007) *Energy Policies of IEA Countries: Germany*. Online. Available at www.iea.org/publications/freepublications/publication/germany2007.pdf (accessed 24 July 2012).

IPCC (2007) *Climate Change 2007: Mitigation*, contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge: Cambridge University Press.

Jahn, D. and Korolczuk, S. (2012) 'German exceptionalism: the end of nuclear energy in Germany!', *Environmental Politics*, 21(1): 159–64.

Jänicke, M. (2008) 'Ecological modernisation: new perspectives', *Journal of Cleaner Production*, 16: 557–65.

Jänicke, M. (2010) 'German climate change policy: political and economic leadership', in R. Wurzel and J. Connolly (eds) *The EU as a Leader in International Climate Change Policy*, London: Routledge, 129–46.

Jänicke, M. (2012) *Megatrend Umweltinnovation: Zur ökologischen Modernisierung von Wirtschaft und Staat*, 2nd edn, Munich: oekom.

Marcantonini, C. and Ellerman, A.D. (2013) *The Cost of Abating CO2 Emissions by Renewable Energy Incentives in Germany*, EUI Working Paper RSCAS 2013/05, European University Institute. Online. Available at http://cadmus.eui.eu/bitstream/handle/1814/25842/RSCAS_2013_05rev.pdf?sequence=1 (accessed 21 July 2013).

Monopolkommission (2011) *Energie 2011: Wettbewerbsentwicklung mit Licht und Schatten*, Special Report No. 59, Baden-Baden: Nomos.

OECD (2012) *OECD Environmental Performance Reviews: Germany 2012*. Online. Available at http://dx.doi.org/10.1787/9789264169302-en (accessed 12 March 2013).

Pearce, D. (2002) 'An intellectual history of environmental economics', *Annual Review of Energy and the Environment*, 27: 57–81.

Posen, A. (2008) 'Exportweltmeister – so what? Better goals for German foreign economic policy', in R. Schettkat and J. Langkau (eds) *Economic policy proposals for Germany and Europe*, London: Routledge, 119–43.

Prat, A.G. (2010) 'Effective regional energy governance – not global environmental governance – is what we need right now for climate change', *Global Environmental Change*, 20: 33–5.

Schreurs, M.A. (2010) 'German perspectives on ecological modernization, technology transfer, and intellectual property rights in the case of climate change', in American Institute for Contemporary German Studies (ed.) *AICGS Policy Report No 45*, Washington: The Johns Hopkins University, 61–77.

Seippel, Ø. (2000) 'Ecological modernization as a theoretical device: strengths and weaknesses', *Journal of Environmental Policy & Planning*, 2: 287–302.

Stefes, C.H. (2010) 'Bypassing Germany's Reformstau: The remarkable rise of renewable energy', *German Politics*, 19(2): 148–63.

SVR (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung) (2011) *Verantwortung für Europa wahrnehmen*. Online. Available at www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/Sonstiges/chapter_six_2011.pdf (accessed 15 March 2013).
SVR (2012) *Stabile Architektur in Europa – Handlungsbedarf im Inland*. Online. Available at www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/gutachten/ga201213/ga12_ges.pdf (accessed 25 November 2012).
SVU (Sachverständigenrat für Umweltfragen) (2011) *Wege zur 100% erneuerbaren Stromversorgung*, Special Report. Online. Available at www.umweltrat.de/SharedDocs/Downloads/DE/02_Sondergutachten/2011_07_SG_Wege_zur_100_Prozent_erneuerbaren_Stromversorgung.pdf;jsessionid=F0333D6E19D7500FD90B75FC07915AFB.1_cid325?__blob=publicationFile (accessed 10 June 2012).
Torvanger, A. and Meadowcroft, J. (2011) 'The political economy of technology support: making decisions about carbon capture and storage and low carbon energy technologies', *Global Environmental Change*, 21: 303–12.
Weber, M. and Hey, C. (2012) 'Effektive und effiziente Klimapolitik: Instrumentenmix, EEG und Subsidiarität', *Wirtschaftsdienst*, 92(13): 43–51.
World Bank (2013) 'World Development Indicators'. Online. Available at http://databank.worldbank.org/data/views/reports/tableview.aspx (accessed 22 July 2013).
Wurzel, R.K.W. (2010) 'Environmental, climate and energy policies: path-dependent incrementalism or quantum leap?' *German Politics*, 19(3): 460–78.
York, R. and Rosa, E.A. (2003) 'Key challenges to ecological modernization theory', *Organization & Environment*, 16(3): 273–88.