Germany's Energiewende: A Tale of Increasing Costs and Decreasing Willingness-To-Pay

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In recent years, the political economy of electricity provision in Germany has been strongly influenced by two factors. The first is the country's ongoing commitment to increase the share of renewable energy technologies, with green electricity production amounting to almost 33% of gross consumption by the end of 2015 (BDEW, 2016:11). The second factor is the nuclear catastrophe at Japan's Fukushima in 2011. This event had a profound impact in exacerbating a longstanding skepticism in Germany on the merits of nuclear power, and led to the legal stipulation of its phase-out in the same year. Both factors are the most salient pillars of Germany's so-called Energiewende (energy transition), which advances the most ambitious subsidization program in the nation's history, with costs that may approach those of German re-unification.

Summarizing the paper of Andor, Frondel, Vance (2017), which will be published in a forthcoming Special Issue of The Energy Journal, we present evidence that the accumulating costs of Germany's Energiewende are butting up against consumers' willingness-to-pay (WTP) for it. We begin with a descriptive overview of the growth of renewable energy technologies in Germany since the introduction of the Renewable Energy Act in 2000, focusing on increases in both capacity and the associated costs. Thereafter, we turn attention to the public's acceptance of these costs, which have to be born by electricity consumers via a surcharge on their bill.

IMMENSE COSTS OF RENEWABLE CAPACITY EXPANSION

In Germany, electricity generated from renewable energy sources (RES) has preferential access to the grid and is promoted via a feed-in-tariff (FIT) system that guarantees technology-specific, above-market rates, commonly over a 20-year time period. This promotion scheme has established itself as a global role model and has been adopted by a wide range of countries (CEER, 2013). In fact, FIT systems have been established in more than 100 countries throughout the world (REN21, 2015).

Since the implementation of Germany's FIT system in 2000, installed capacities of renewable energy technologies have increased remarkably, by more than eightfold between 2000 and 2016 (Table 1). Photovoltaics (PV), until recently the most expensive renewable energy technology in Germany (Frondel, Ritter, Schmidt, 2008), and onshore windmills have experienced the largest increase, with PV capacities sky-rocketing: In 2010 alone, more than 7,000 Megawatt (MW) were installed, an amount that exceeded the cumulated capacities installed by 2008. According to estimations of Frondel, Schmidt, Vance (2014: 9), the real net cost for all those modules installed between 2000 and 2015 amounts to more than 110 billion Euros.

In 2016, total RES capacities reached about 104 Gigawatts (GW), equaling those of conventional power plants (last column Table 1), while the share of green electricity in gross electricity consumption was about 32% (BMWi, 2017: 5). This relatively modest share owes to the fact that wind and solar power are not permanently available 24 hours a day. Consequently, to reach Germany's renewable goals of a 50% share in gross electricity consumption set for 2030 and 80% in 2050, a multiple of today's capacities have to be installed, an endeavor that will inevitably lead to higher costs of electricity generation.

These costs were already substantial in the past: Between 2000 and 2015, consumers paid about 125 billion Euros in the form of higher electricity bills for Germany's RES promotion (Table 2), with the cost shares of industrial and household consumers estimated at 31.5% and 34.5% in 2016,

Year	Hydro Power	Wind Onshore	Wind Offshore	Photo-Voltaics	Biomass	Total RES Capacities	Conventional Capacities
2000	4.83	6.10	–	0.11	0.70	11.75	109.9
2001	4.83	8.74	–	0.18	0.83	14.57	107.9
2002	4.94	11.98	–	0.30	1.03	18.24	106.5
2003	4.95	14.59	–	0.44	1.43	21.41	105.6
2004	5.19	16.61	–	1,11	1.69	24.59	106.0
2005	5.21	18.38	–	2.06	2.35	27.99	107.0
2006	5.19	20.57	–	2.90	3.01	31.67	107.6
2007	5.14	22.18	–	4.17	3.50	34.99	110.2
2008	5.16	23.82	–	6.12	3.92	39.02	110.4
2009	5.34	25.63	0.06	10.57	4.55	46.14	111.4
2010	5.41	27.01	0.17	17.94	5.09	55.61	111.6
2011	5.63	28.86	0.20	25.43	5.77	65.87	103.2
2012	5.61	31.00	0.31	33.03	6.18	76.10	102.1
2013	5.59	33.76	0.51	36.34	6.52	82.71	103.9
2014	5.61	38.16	1.04	38.24	6.87	89.91	104.3
2015	5.90	41.24	3.30	39.80	6.90	96.83	104.1
2016	5.60	45.38	4.15	41.28	7.11	103,52	103.2

Table 1: Germany's Conventional and Renewable Electricity Generation Capacities in Gigawatt (GW).

Sources: BMWi (2016: 12, 2017: 7), BDEW (2016: 13). With an installed capacity of less than 0.05 GW in 2014, geothermic systems are of negligible relevance and not included in the table.

Year	Hydro Power (Bn. €)	Wind Onshore (Bn. €)	Wind Offshore (Bn. €)	Photo-Voltaics (Bn. €)	Biomass (Bn. €)	Total RES Net Costs (Bn. €)	Average Net Costs per kWh (Cents/kWh)
2000	0.213	0.397	–	0.014	0.042	0.667	6.4
2001	0.295	0.703	–	0.037	0.105	1.139	6.3
2002	0.329	1.080	–	0.078	0.177	1.664	6.7
2003	0.253	1.144	–	0.145	0.224	1.765	6.2
2004	0.195	1.520	–	0.266	0.347	2.430	6.3
2005	0.193	1.518	–	0.636	0.540	2.997	6.8
2006	0.168	1.529	–	1.090	0.896	3.765	7.3
2007	0.121	1.428	–	1.436	1.307	4.338	6.5
2008	0.081	1.186	–	1.960	1.565	4.818	6.8
2009	0.025	1.608	0.003	2.676	1.991	5.301	7.0
2010	0.192	1.647	0.019	4.465	3.000	9.525	11.6
2011	0.263	2.145	0.057	6.638	3.522	12.774	12.4
2012	0.223	2.944	0.092	7.939	4.576	16.008	13.5
2013	0.303	3.165	0.122	8.276	5.172	17.340	13.8
2014	0.301	3.669	0.208	9.166	5.675	19.222	14.1
2015	0.306	4.136	1.717	9.402	5.552	21.066	13.1
Total Costs	3.460	28.818	2.218	54.221	34.689	124.821	–
Cost Shares	2.8%	23.1%	1.8%	43.4%	27.8%	100 %	–

Table 2: Net Costs of Germany's Promotion of Renewable Energy Technologies in Billions of Euros.

Source: BMWi (2015). Figures for 2015 are unconsolidated forecasts.

respectively (BDEW, 2016:60). The remaining 34% are contributed by commerce, trade, services (18.8%), the public sector (12.2%), transport (2.1%) and agriculture (0.9%).

The strong increase in alternative electricity generation capacities in Germany and the resulting rise in the share of green electricity in consumption led to a surge in the surcharge that appears on German electricity bills (Figure 1). In 2015, the surcharge of 6.17 cents per kWh comprised roughly 20% of the average per-kWh price of electricity of about 28 cents (Table 3). The increase of this surcharge is particularly pronounced in the years between 2009 and 2014, a period that largely coincides with the stark extension of PV capacities. In fact, the exploding PV capacity increases in the years 2009-2012 (Table 1) were responsible for the near doubling of average subsidies per kWh between 2009 and 2013 (last column in Table 2). As a consequence, while comprising about 6% of Germany's annual electricity production (BDEW, 2016:12), PV accounts for 43.4% of total net promotion costs (Table 2), by far the largest cost share among all alternative technologies. The prognosis of 'dark clouds on the horizon' in the subtitle of an earlier analysis by Frondel, Ritter and Schmidt (2008) has thereby materialized, with the subsidies for PV having increased more than 300% since their warning was issued.

Presuming that the annual subsidy level of more than 20 billion Euros in 2015 (Table 2) is extended for the next two decades, a crude back-of-the-envelope calculation yields an estimate of 400 billion Euros for the continued promotion of renewable energy. Several considerations render this estimate conservative. First, the annual subsidies are likely to far exceed 20 billion Euros in light of their inexorable increase to date. According to a recent forecast, they will approach 30 billion in 2020 (BDEW, 2016:83), in large part owing to the expansion of offshore-wind capacities, currently the most expensive green technology in Germany.

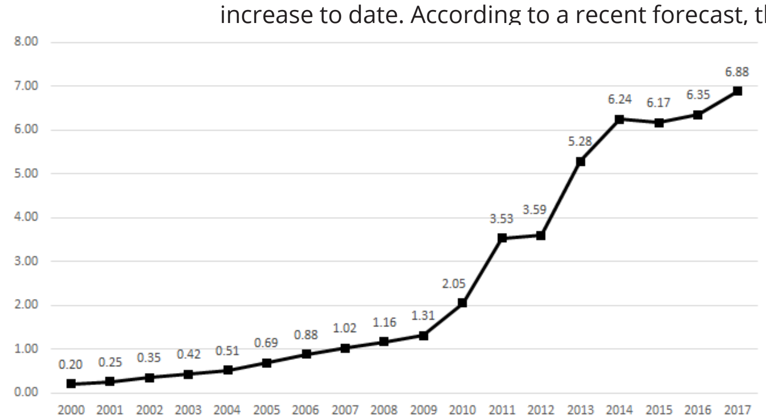

Figure 1: Surcharge on Electricity Prices (in Cents per kWh) to Support Green Electricity (BDEW 2016:60)

Additional costs arise due to the fact that a large portion of today's conventional power plants has to be sustained to compensate for the intermittency of wind and solar power, since storing volatile green electricity is likely to remain unprofitable for the next decades (Frondel, Sommer, Vance 2015). Not least, substantial costs of several tens of billions of Euros accrue to consumers from the indispensable expansion of power grids, in particular as the electricity produced by wind power installations in the north and east of Germany must be transported to the highly industrialized west and south of the country. In short, it is most likely that future electricity prices will rise further if Germany actually reaches its renewable goals.

Some sense for the extent of the likely rise can be gleaned from past developments. Between 2000 and 2015, electricity prices more than doubled, from 13.94 to 28.68 ct/kWh (BDEW, 2016:56). For typical households with an electricity consumption of 3,500 kWh per annum, this implies an additional burden of about 520 Euro per year. In terms of purchasing power parities (Table 3), German households now incur the highest power prices in the European Union (EU). In a similar vein, prices for industrial customers are also among the highest in the EU.

BENEFITS OF RENEWABLE CAPACITY EXPANSION

Of course, whether these high costs are justified from a social-welfare perspective depends on the size of the benefits associated with the promotion of renewable energy technologies, a quantity that is considerably more difficult to calculate than the costs and one that is beyond the scope of the analysis by Andor, Frondel, Vance (2017). The majority of studies that have tackled this issue have focused on quantifying specific benefit categories, such as carbon dioxide (CO_2) emissions reductions and innovation effects, or have investigated economic impacts, such as job creation. In addition, in the absence of appropriate policy instruments, an important co-benefit of the use of renewable energy technologies is the reduction of local air pollution and associated health impacts due to the avoidance of local emissions of particulate matter and nitrous oxides from burning fossil fuels.

	Household Prices	Industrial Consumption in Gigawatthours < 500	< 2,000	< 20,000	< 70,000	< 150,000
Denmark	22.8	26.73	25.90	25.87	24.37	24.18
Germany	28.3	22.76	19.79	17.49	15.05	13.88
Italy	24.4	22.64	18.79	16.65	13.64	11.14
Austria	18.2	14.95	12.47	10.77	9.17	8.32
United Kingdom	16.6	20.05	17.88	16.44	16.03	15.65
Netherlands	17.9	18.06	11.06	9.89	8.51	8.49
France	14.8	14.42	12.08	10.53	9.22	7.71
EU 28	20.8	16.00	13.24	11.74	10.41	13.04

Table 3: Electricity Prices in Euro Cents per kWh for European Household and Industrial Consumers in 2015

Source: Eurostat (2016). Average Prices including Taxes and Levies in Purchasing Power Standards.

Perhaps the most important economic benefit relates to climate change mitigation. The record here is inauspicious. Germany's CO_2 emissions have been relatively stagnant in recent years, even rising somewhat in 2016, and an expert commission appointed by the country's minister of economy and energy has cast skepticism on reaching the target set for 2020 of a 40 percent reduction in CO_2 relative to 1990 (Löschel et al., 2016).

One reason is the country's continued reliance on fossil sources to bridge the intermittency of renewables. Mainly due to the nuclear phase-out, coal use has maintained a relatively stable share in Germany's electricity generation, amounting to about 42% in 2015 (AGEB, 2016). By contrast, the use of natural gas, which is much less emissions-intensive than coal, is on the decline, with its share in electricity production decreasing from 14.1% to 9.4% between 2010 and 2015.

Equally important is Germany's membership in the European Trading System (ETS), which sets a binding cap on the emissions of participating countries and consequently renders the feed-in tariff system redundant. Germany's success in unilaterally reducing its emissions through feed-in tariffs releases tradable emissions certificates, thereby reducing their price and resulting in higher emissions elsewhere in Europe.

SHRINKING WILLINGNESS TO PAY FOR GREEN ELECTRICITY

The foregoing analysis has documented the substantial costs of Germany's support scheme for renewable energy technologies, which are likely to exceed 400 billion Euros over the next 20 years. Given the now decade-plus history of unabated cost increases, coupled with the prospect that this trend will continue into the foreseeable future, the question arises as to the public's tolerance for continued support of Germany's Energiewende.

Drawing on two stated-preference surveys conducted in 2013 and 2015 that elicit households' willingness-to-pay for green electricity, the results presented by Andor, Frondel, Vance (2017) suggest tepid support for financing renewable energy technologies. In fact, the open-ended responses reveal a marked decrease of about 17% in the average willingness-to-pay between the 2013 and 2015 waves of the survey, a period during which the surcharge paid by households for green electricity rose commensurately, by 17%.

The shrinking willingness-to-pay for green electricity and the cost burden notwithstanding, the data analyzed by Andor, Frondel, Vance (2017) suggests that the German public, at least in principle, is highly supportive of RES technologies. Based on the 2015 wave of the survey, some 88% of respondents stated that RES should generally be supported, a finding that is buttressed by other polling (e. g., Statista, 2016). Overall, the survey results highlight a strong contrast between the households' general acceptance of supporting renewable energy technologies and their own willingness-to-pay for green electricity: On the one hand, the share of respondents who agreed with the statement that, in principle, renewable energy technologies should be supported increased from 84.4% in 2013 to 88.0% in 2015. On the other hand, almost 60% of those household heads who participated in both surveys reduced their willingness-to-pay for 100% green electricity relative to 2013.

CONCLUSION: MORE COST-EFFECTIVENESS

Presuming that subsequent surveys reveal a continued decrease in the willingness-to-pay for green electricity, the public's resistance to increasing electricity prices may force a discussion that leads to a restructuring of Germany's energy transition and climate protection policy, which is currently costing the country more than 0.8% of its GDP per year. Resistance may be further exacerbated as recognition grows of the marginal environmental benefits of the Energiewende coupled with absence of positive economic impacts, such as employment creation. In this regard, the longstanding narrative surrounding 'green jobs' has instead been contradicted by a series of bankruptcies in the photovoltaics sector, the most recent being the insolvency of Germany's largest PV-manufacturer Solarworld, announced in May of this year.

In short, high costs of the promotion of renewables of about 25 billion Euros per annum together with minor environmental benefits render Germany's feed-in tariff system highly cost-ineffective, a point that has been recognized by several expert commissions, such as the German Council of Economic Experts (GCEE, 2011: 219) and the International Energy Agency (IEA, 2007:76). To improve cost-effectiveness and dampen future electricity price increases, the German government has recently introduced an auctioning system for the renewable energy technology promotion, where capacities are auctioned separately by technology to foster competition among providers. As these auctions are technology-specific, though, there is still no competition across technologies. Cost-effectiveness could be further improved if future capacities were to be increased by technology-neutral auctions.

More desirable, from the perspective of consumers, would be a fundamental reform of the support scheme that involves a switch to a technology-neutral quota system (GCEE, 2011) or the subsidization of capacities, rather than electricity generation (Andor, Voss 2016), both of which would make the suppliers of green electricity more responsive to the demand side. An additional increase in cost-effectiveness would be achieved if support schemes for renewable energy technologies were to be coordinated at the European level, as is called for by the European Commission, thereby recognizing that green electricity production may be cheaper in Europe's southern periphery, where the sun intensity is high.

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