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Renewable energies

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Renewable energies

Contents

The success of renewable energies and their expansion in Germany poses great challenges to policy and society in terms of technology, financing, and acceptance, but offers many opportunities at the same time. The various overlapping constellations of interests and stakeholders on different scales in the area of renewable energies are diverse. They go hand in hand with an altered geography of energy supply and lead to new governance structures.

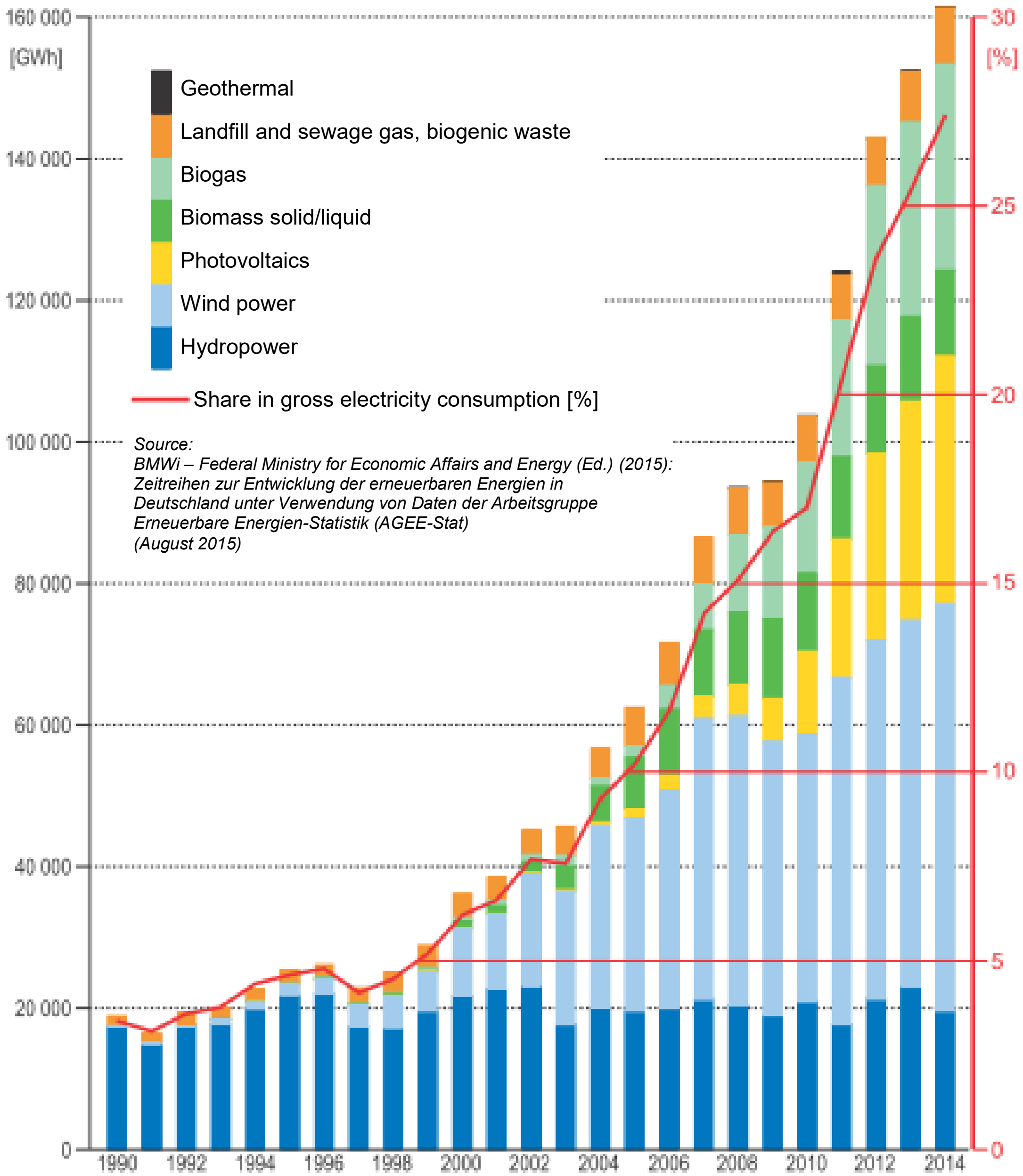
1 Dynamic development and complex governance structures

The energy transition – and therefore the expansion of renewable energies – has made progress in Germany. More than one-fourth of the annual electricity generation in Germany today comes from renewable energy plants (see Fig. 1). These plants use energy offered by nature in form of direct (e.g. photovoltaic (PV), solar thermal energy) or indirect (e.g. wind, biomass) solar radiation and convert it into electricity, heat, or both. The expansion of renewable energy plants reached a new high point in 2013, which many critics – primarily in the ▷ *Energy industry* itself – still believed unattainable in the 1990s. Therefore, Germany played a trailblazing role both internationally and within the EU (▷ *European Union*), especially when compared with other large industrial nations such as Japan or the US (see Fig. 2).

The starting point for the politically motivated energy transition was the Electricity Feed-in Act *(Stromeinspeisungsgesetz)* passed by the German Federal Parliament in 1990 (*StromEinspG*: the Act on Feeding in Electricity from Renewable Energies into the Grid of 7 December 1990, *BGBl.* [Federal Law Gazette] 1990 I, 2633; significantly amended on 28 April 1998, *BGBl*. 1998 I, 730-736). It took effect on 1 January 1991 and aimed to oblige electricity providers to buy and pay remuneration for electricity generated from renewable primary energy sources (water, wind, sun, landfill and sewage gas, and biomass). In accordance with the law, the renewable energy was remunerated with at least 75% (even 90% for solar and wind power) of an energy provider's average revenues per kilowatt hour (kWh). In addition to the price regulation, the purchase obligation was a significant political innovation: for the first time, it questioned the energy providers' regional monopoly that had been in place until then. With the liberalisation of the energy market in the EU (inter alia Directive 1996/92/EC) or at a national level (Amendment to the Energy Industry Act *(Energiewirtschaftsgesetz, EnWG)* of 1998; *BGBl*. 1998 I, 730-736), this regional monopoly was further broken up by 'unbundling', among other measures.

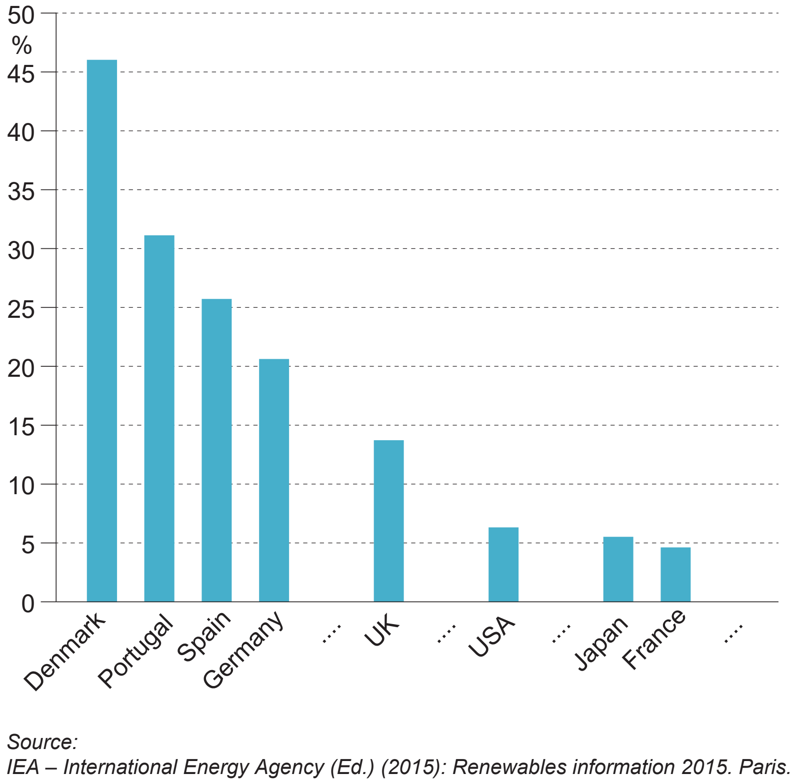
The Electricity Feed-in Act is considered successful, especially if measured by the expansion of wind power, and, after it withstood scrutiny before the Federal Court of Justice *(BGH)* in 1996 (*BGH* judgment of 22 October 1996, case no. KZR 19/95; *BGHZ* [Decisions of the Federal Court of Justice on Civil Matters] 134, 1), it became the Act on Granting Priority to Renewable Energy Sources, otherwise known as the Renewable Energy Act *(Erneuerbare-Energien-Gesetz, EEG)* of 2000 (*BGBl*. 2000 I, 305-309). The new statutory orientation was based firstly on the growing environmental awareness and discussions on reducing greenhouse gas emissions (inter alia the Kyoto Protocol 1997). Secondly, the legislature also had to take into account the increasing level of expansion of renewable energies (particularly wind), especially since the coupling of the remuneration rates with electricity prices could by that point no longer guarantee the economic operation of some renewable energy plants. Thus, one important (if not the most important) new aspect was establishing binding minimum feed-in tariff rates per kilowatt hour produced, depending on the energy source or technology (water, wind, sun, geothermal energy, landfill, sewage or mine gas, biomass, wind power or solar energy) over a 20-year period. The financing comes from a levy paid by electricity consumers, known as the 'EEG levy', which balances out the difference between the feed-in remunerations and the electricity price. There is also the regulation on the obligation to connect and the priority of the generated electricity from renewable energies compared to conventional energy sources, to ensure that fluctuating electricity is fed into the grid without discrimination. Thanks to those innovations, the investment risk fell and debt capital became easier to access, so that the Renewable Energy Act was followed by an investment boom with a rapidly increasing number of new renewable energy plants (see Figs. 1 and 3).

Figure 1: Development of electricity generation from various renewable energy sources in Germany, 1990–2014



Source: The authors, based on data from the Federal Ministry for Economic Affairs and Energy (BMWi) 2015a

Figure 2: Share of renewable energies (without hydropower) in electricity generation in selected OECD countries, 2013

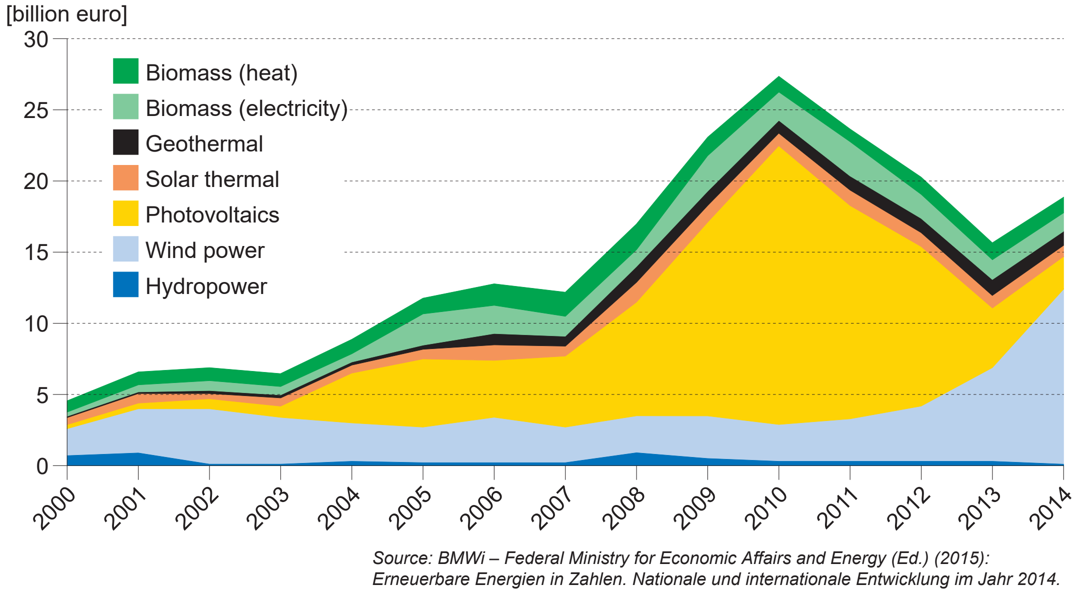


Source: The authors, based on IEA 2015

Against opposition from the conventional energy industry and industrial associations that wanted to restrict renewable energies subsidies, the Federal Court of Justice found the purchase and remuneration obligations to be constitutional in two judgments of 2003 (Federal Court of Justice judgment of 11 June 2003, case no. VIII ZR 160/02, *BGHZ* 155, 141; Federal Court of Justice judgment of 8 October 2003, case no. VIII ZR 165/01, *BGHR* 2004, 74). This was followed by amendments to the Renewable Energy Act in 2004, 2008, 2009 and 2012, which essentially contained specifications and supplements, such as those due to technical developments (e.g. the 2012 amendment on photovoltaics (PV Amendment): cost reduction for PV modules, stronger degression (*BGBl.* 2012 I, 1754), supra-national regulations (e.g. directives on the internal electricity market of the EU) or unintended developments and excessive subsidies (e.g. the Bonus for Electricity Generated from Renewable Raw Materials *[Bonus für Strom aus nachwachsenden Rohstoffen, NaWaRo-Bonus]* 2004 and the Manure Bonus *[Güllebonus]* 2008/2009, which were withdrawn in 2012). In addition, the expansion goals were continually adjusted upward to keep pace with actual developments.

The last reorientation of the Renewable Energy Act occurred in 2014, with the 'Renewable Energy Act 2.0' (*BGBl*. 2014 I, 1066). With the Renewable Energy Act 2.0, the legislature sought to counter the increasingly critical discussions on the growing EEG levy and the exemption of energy-intensive industries from paying a levy, and concerns about network stability. To gain more efficient control of the expansion, cost development and market appropriateness of the subsidy for renewable energies, the departmental responsibility was centralised in the Federal Ministry for Economic Affairs. Specifically, the new aspects included 'the flexible cap', i.e. annual upper limits on quantities for the expansion of PV (2.5 GW p.a.), onshore wind power (2.5 GW p.a.) and biomass (100 MW p.a.), and for offshore wind (6.5 GW by 2020 or 15 GW by 2030); any expansion to renewable energy plants beyond that will receive lower subsidy rates.

Figure 3: Investments in renewable energy plants in Germany, 2000–2014



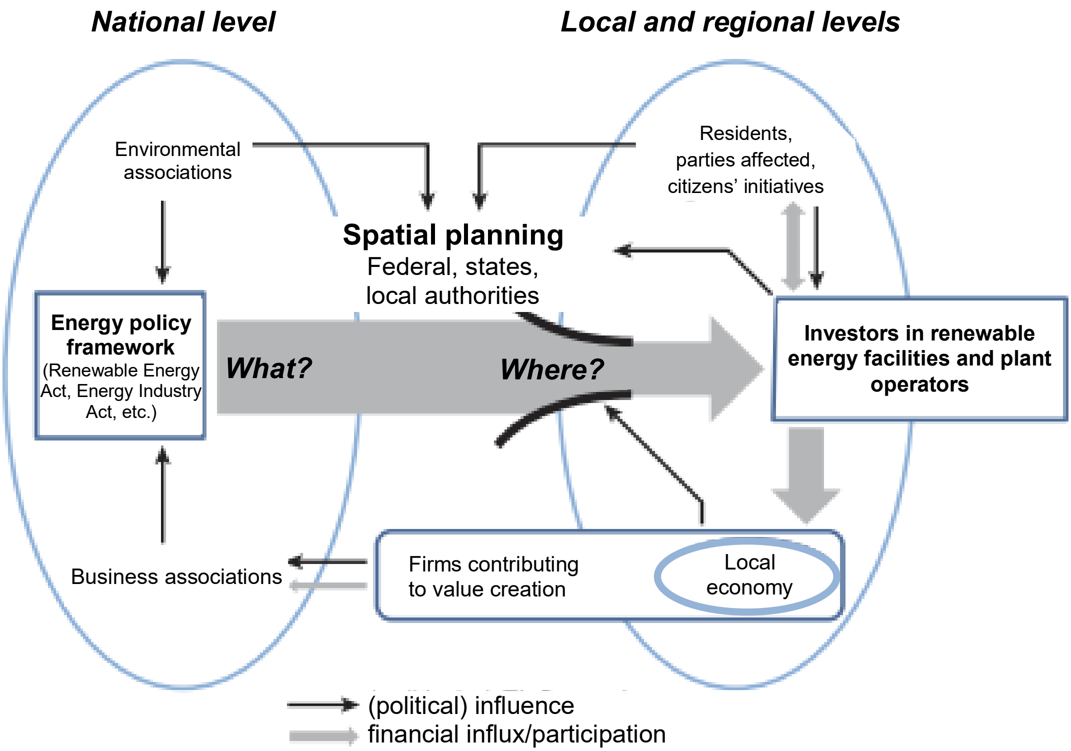
Source: The authors, based on data from the Federal Ministry for Economic Affairs and Energy (BMWi 2015b)

Another important goal of the new version of the Act in 2014 aims to integrate renewable energies into the energy market. To that end, a tendering model, in which the amount of the subsidy for energy was determined via a public, transparent competition among bidders, was introduced until 2017 (although initially only for PV ground-mounted installations). Furthermore, direct marketing (which was already practiced) is taking on a greater role, and will be applied mandatorily and gradually, in descending order of capacity, until renewable energy plants of 100 kW of capacity are affected. This paradigm shift continued with the revision of the Renewable Energy Act in 2017 (*BGBl*. 2016 I, 2258). The tendering model is now also used in wind power and solar energy (for all plants >750 kW) and biomass (>150 kW). The clear orientation towards energy market integration shows that the legislature is increasingly interested in large, professionalised market players and that the population at large – so far a mainstay in financing the expansion of renewable energies – could fall behind.

The national ▷ *Energy policy*, especially the post-Fukushima decision in 2011 to phase out nuclear energy, was aimed at a fundamental transformation of the energy system towards renewable energies (80% of electricity to be supplied from renewable energies by 2050; section 1(2) of the Renewable Energy Act). This has far-reaching implications arising above all from the new demands for space for renewable energies, the associated land-use conflicts, and acceptance problems on a local level. Other uses of those sites, such as for ▷ *Nature conservation*, ▷ *Tourism*, ▷ *Agriculture* and ▷ *Housing*, all compete against renewable energies for the right to use those sites and stand to be disrupted by their use for renewable energies. To that end, energy policy and ▷ *Spatial planning (Raumplanung)* play a key role in expanding and subsidising renewable energies.

For Germany, therefore, there is a duality in the governance structures for renewable energies (▷ *Governance*): on the one hand is the coordination across the market, framed by incentive structures through nationally determined feed-in remunerations (see Fig. 4). And on the other hand is the multi-level system of ▷ *Planning*, in which specific decisions on locations and power transmission lines are mostly made on the local and regional levels. Since 2011, the national level has become responsible merely for clarifying needs and making decisions on expanding the extra-high voltage grid. Therefore, from an analytical viewpoint, two fields of governance can be delineated: a financial/economic and a planning governance field, both of which are relevant for expanding renewable energies; both fields of governance take different forms and occur on different levels.

Figure 4: Duality of the governance structures for renewable energies



Source: The authors, based on Klagge 2013

In both governance fields, economic, environmental, and social interests come into play, although their spatial references differ. Furthermore, various stakeholders with diverse and sometimes very different interests and resources participate in the corresponding negotiation and decision-making processes. These include stakeholders at all political and administrative levels (federal, state, region, local authority and the EU), mainly in the areas of energy policy and spatial planning. Alongside these, additional stakeholders, including firms, mainly from the energy industry (along with network operators) and the agrarian sector (primarily farms), as well as civil society organisations (associations, citizens' initiatives and action groups, etc.) attempt to influence policy decisions. Finally, citizens have played an important role thus far, both as those affected by the planning and as proponents or opponents, and ultimately as (potential) investors. To that end, interesting differences arise between the renewable energy technologies due to specific land and planning needs, among other things.

2 Different renewable energy technologies and the challenges of network development

Wind power, biomass, photovoltaic, solar thermal, landfill gas, sewage gas, mine gas, and hydropower plants are all used to generate electricity from renewable sources. Each of these types of electricity generation is based on different technologies with different characteristics, and each has seen a different degree of expansion and technological maturity (see Table 1).

Compared to other types of renewable energy, wind turbines are particularly mature. The historical roots of converting wind into power go back to the 19th century, when wind pioneers, mostly from the fields of agriculture or agricultural technology, developed various technologies and installation models in close coordination with producers (cf. Heymann 1995; Karnøe/Garud 2012; Simmie 2012). However, especially in the interwar and postwar period, the low-capacity niche or 'insular' solutions that were detached from the public supply grid and used in rural, peripheral regions could no longer meet the increasing energy needs (stemming from reconstruction or the 'German economic miracle'). Instead, rapid, large-scale, and above all economic electricity supply was guaranteed by an energy system geared towards fossil (and later, also nuclear) energy sources while the network infrastructure was expanded at the same time.

With the oil crises of the 1970s, the Chernobyl incident of 1986 and a growing environmental movement, wind power – together with other alternative energy sources – experienced renewed public interest (cf. Heymann 1995; Oelker 2005; Bruns/Köppel/Ohlhorst et al. 2008). Various large-scale research projects (including *GroWiAn* [large wind turbine]) should have forced the technological *leap frogging* into the MW class, but ultimately failed owing to the lack of experience of the participating stakeholders in wind technology (cf. Pulczynski 1991; Oelker 2005). In parallel, market-ready technologies developed from niche solutions by means of incremental innovations (e.g. the *Danish Design*) and caught on internationally (cf. Campos Silva/Klagge 2011). With the political subsidies and increasing liberalisation of the energy markets at the turn of the millennium, wind power finally became a growth sector in Germany and Europe, and later worldwide. The global increase in capacity of just about 1.5 GW of installed capacity (1990) to over 370 GW in 2014 (cf. GWEC 2015) testifies to the enormous growth and associated sectoral dynamics that have promoted wind power to the fastest-growing and technologically most advanced renewable energy.

Table 1: Technology-specific overview of the various renewable energy plants and their installed capacity in Germany

Technology		Gross electricity production (2014, in GWh)	Installed capacity in Germany (2014, in MW)	Investment in construction (2014, in € billion)	Levelized costs of energy[1] in Germany (in the third quarter of 2013, in €/kWh)
Wind power	Onshore	55,908	38,156	6.9	0.045-0.107
	Offshore	1,449	1,037	5.4	0.119-0.194
Solar energy	Photovoltaics	35,115	38,236	2.3	0.078-0.142
	Solar thermal	—	—	0.8	—
Bioenergy	Biomass	12,120	2,332	1.3 (electricity) 1.1 (heat)	—
	Biogas	29,140	4,080	—	0.135-0.215
Hydropower		19,590	5,614	0.1	—
Geothermal		98	24	1.0	—
Landfill and sewage gas, biogenic waste		7,959	2,379	—	—
Total renewable energies		161,379	91,858	18.9	—

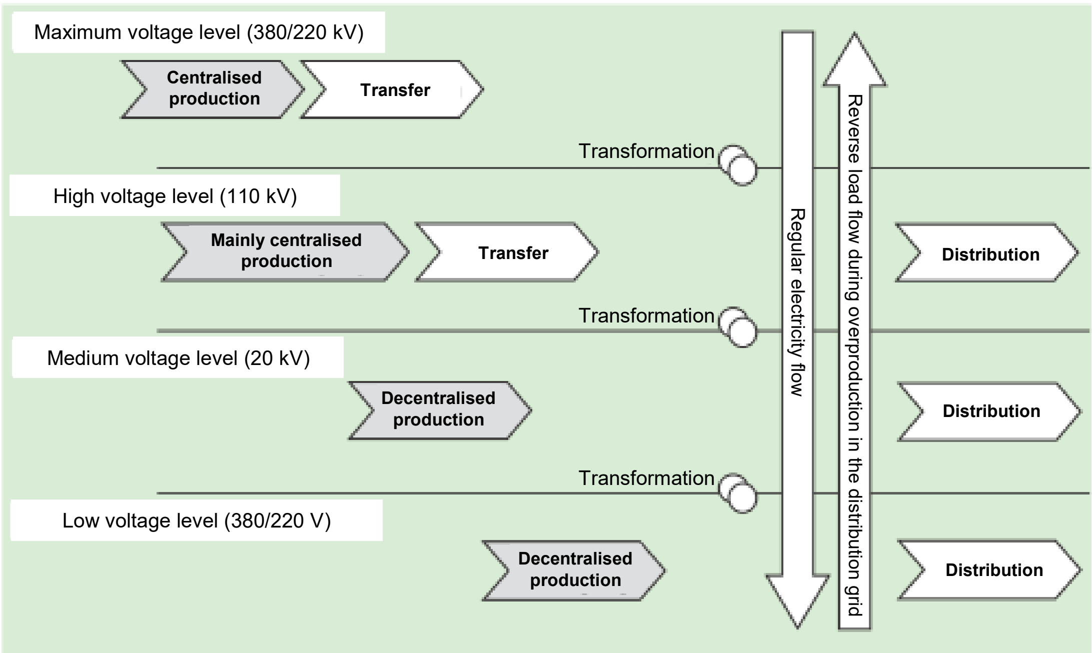
[1] Levelized costs of energy are a proxy for comparing the costs of fluctuating electricity production technologies. They represent weighted average costs based on investments and on income and expenditures over the entire life span, and essentially depend on site conditions (wind conditions, exposure, etc.). The actual value of the electricity is determined by the fluctuations in supply and demand during different times of day.

Sources: Fraunhofer ISE 2013; BMWi 2015a; BMWi 2015b

Through technological and organisational innovations, large projects, especially offshore, have now become technically feasible and, owing to the availability of subsidies, economically realisable. Not least for that reason, the capital-intensive wind industry – in 2014, over €12 billion was invested in the erection of wind turbines in Germany alone (see Table 1) – has become attractive in recent years for international financial stakeholders and institutional investors. The financialisation associated with expanding wind power, i.e. the growing dependence on or influence of financial markets, is especially advanced with wind power – particularly when compared with other renewable energies (cf. Klagge/Anz 2014).

With levelized costs of energy (LCOE) between €0.045 and €0.107 /kWh, wind farms, depending on the site conditions (e.g. wind conditions, full load hours), are already in the cost range of conventional power plants (€0.038 to €0.098/kWh); therefore, wind power is also competitive compared with fossil energy sources (cf. Fraunhofer ISE 2013). It is therefore no wonder that onshore wind power represented the lion's share of renewable electricity generation in 2014, with a gross electricity production of 55,908 GWh (at 38.2 GW installed capacity).

Figure 5: Relations between the power grid levels



Source: The authors, based on Klagge/Brocke 2013: 33

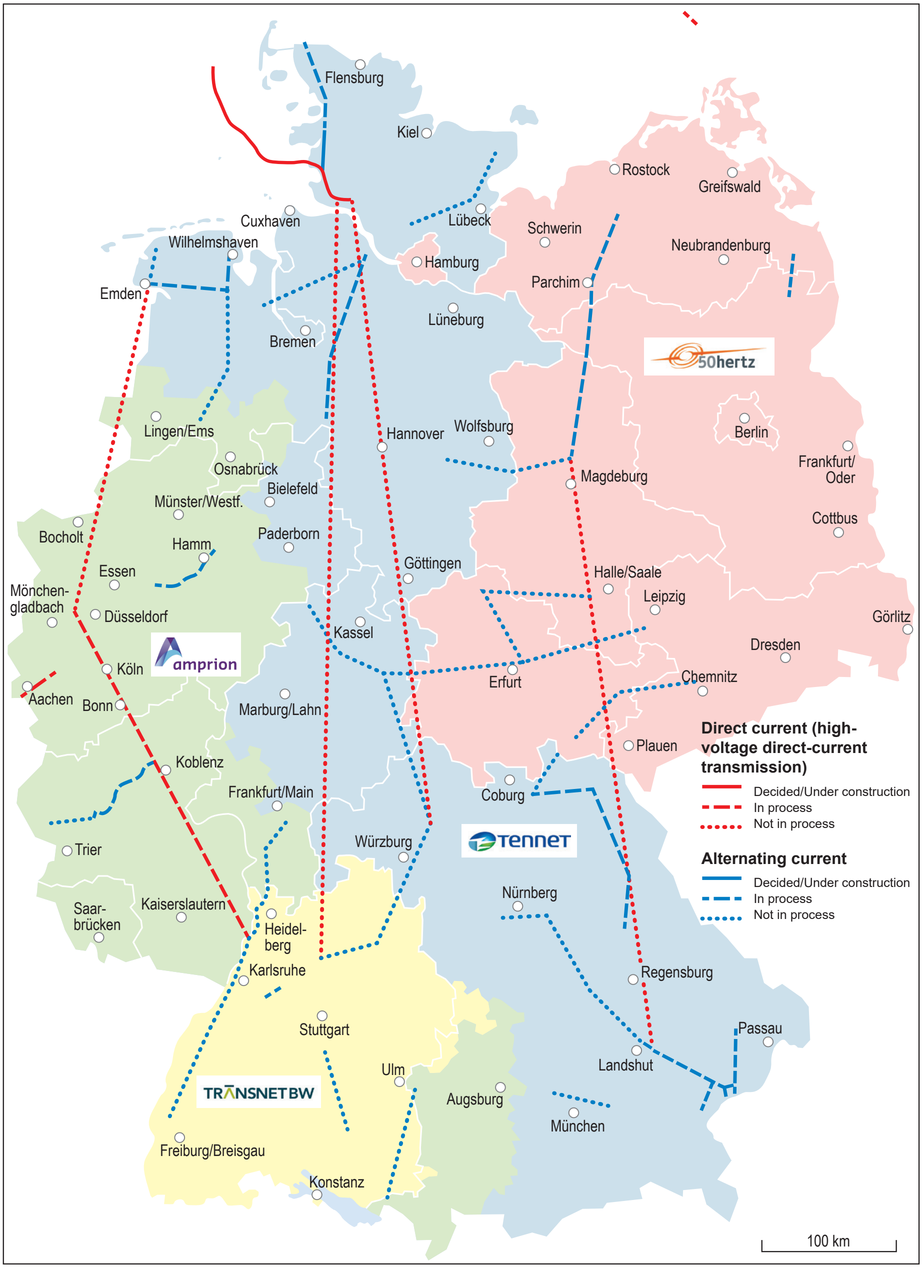
In 2014, wind power was followed by electricity generation from photovoltaics (35,115 GWh), which, thanks to decreasing plant costs caused by growing international competition among plant manufacturers, learning curves and production advances, has also become established in Germany in recent years. By and large, however, the energy harvested from photovoltaics is less than that of wind power, which is reflected in a lower amount of energy from roughly the same installed capacity (see Table 1). In third place is biogas electricity generation (29,140 GWh), which, owing to certain discourses (on the extensive planting of corn for energy purposes, 'tank vs. plate') and changed subsidy conditions, has not grown as strongly in recent years. However, biogas has a technological advantage in that it can be stored and regulated or controlled, so that electricity generation can be adapted according to peak demands in consumption. It therefore plays a potentially important role in system integration, i.e. the technological and competitive integration of renewable energies into the existing supply system.

The growing electricity generation from renewable energies is associated with changing demands regarding the transfer and distribution of the electricity in the grid. The expansion of renewable energies affects the entire energy system regardless of the primary energy sources and technology. As all electricity transport is grid-based, consequences arise for the grid architecture and grid hierarchy, which consists of transmission grids and distribution grids (see Fig. 5). With the liberalisation of the energy market, which entailed a separation of generation and network operations (unbundling), new, independent transmission grid operators (50Hertz, Amprion, TransnetBW, Tennet) have assumed responsibility for the four control zones of the German transmission grid from the four large energy providers. This implies that the grid operators are also responsible for developing and expanding the grid. Expanding renewable energies (and, therefore, decentralised electricity generation in small and medium power plants) represents a special challenge for them, since the security of supply and the grid architecture are essentially still based on centralised electricity generation in fossil fuel or nuclear power plants (cf. *AEE* [Committee on Electrical Power Plants] 2010). With the new renewable energy plants, whose electricity generation sometimes (significantly) fluctuates (with the exception the large offshore wind farms), as well as the cogeneration units feeding into the local and regional distribution grids on lower voltage levels, the load flows are occasionally reversed from down to up.

Locally generated electricity has the advantage that the intake and offtake points are closer to each other and there are fewer grid levels that must be overcome. This reduces transport- and transformation-related grid and voltage losses and saves costs for grid usage. In addition, grid capacities are conserved or saved, whereby the additional need to expand the grid, particularly the 'electricity highways', can be reduced under certain circumstances (cf. Brocke 2012). However, the system integration of renewable energies represents an increasing challenge to grid operators, regulators, the energy industry, and the renewable energy sector (cf. *WBGU* [German Advisory Council on Global Change] 2011; BMWi 2014).

To realise the objective of ensuring security of supply while operating the grid with a high percentage of renewable energies, there are two fundamental, compatible options: (1) efficiently using the available grid structures and modernising them to become '*smart grids*', i.e. intelligent, controllable grids, which allow for the flexible generation of and demand for electricity, while expanding decentralised electricity storage; and (2) expanding or retrofitting the transmission grid through new construction projects to secure the large-scale electricity exchange ('electricity highways'; see Fig. 6). The latter was declared a federally sovereign task in Germany in 2011 with the Grid Expansion Acceleration Act (Transmission Networks) *(Netzausbaubeschleunigungsgesetz Übertragungsnetz, NABEG)*, whereby central decision-making and planning powers (for offshore grid expansion, among other things) were bundled on a national level (sections 2, 4 of the Grid Expansion Acceleration Act (Transmission Networks); cf. Hirschfeld/Heidrich 2013). However, the grid expansion projects continued to face regional and sometimes supra-regional opposition and widespread rejection due to multilayered conflicts regarding land use (cf. Stegert/Klagge 2015). The Federal Cabinet was initially able to satisfy the looming conflicts by prioritising underground cables during line construction, which was already accepted in the Act to Amend Provisions of the Law on Energy Line Construction *(Gesetz zur Änderung von Bestimmungen des Rechts des Energieleitungsbaus)* of 21 December 2015 (*BGBl*. 2015 I, 2490).

Figure 6: Planned projects for new grid construction (corridors) and the control zones of the transmission grid operators in accordance with the Federal Requirement Plan Act *(Bundesbedarfsplangesetz, BBPlG)* **– status as of 2015**



Source: The authors, based on the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway *(Bundesnetzagentur, BNetzA)* **2015**

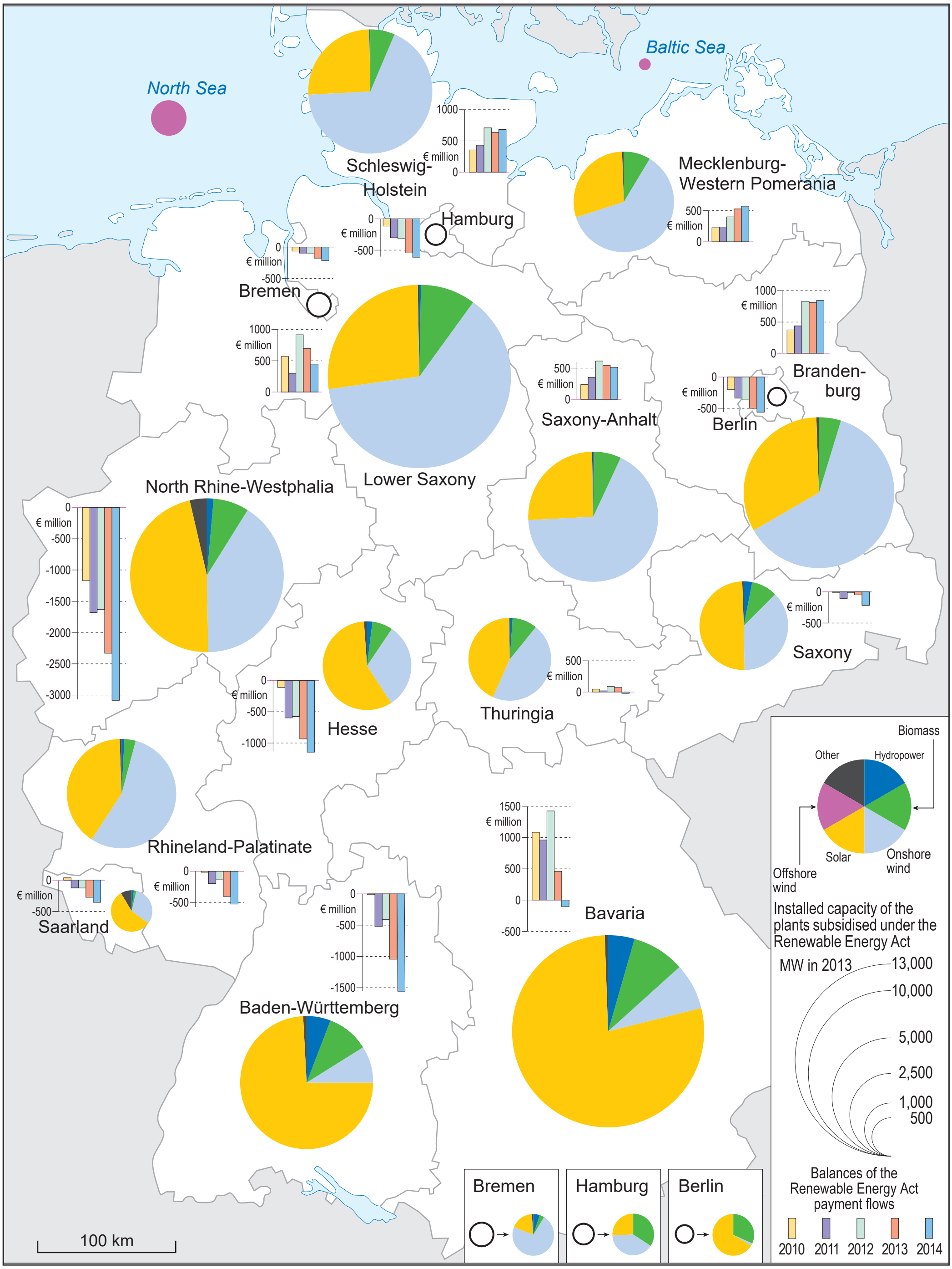
3 The geography of renewable power plants and associated economic benefits

The challenges of developing grids primarily lie in the decentralised but unequal spatial distribution of renewable energy power plants. This is due to institutional factors as well as differences in geographical conditions that favour specific technologies. Moreover, the geography of the economic benefits associated with the energy transition is especially important in the context of the current controversies. For example, the energy transition and the (regionally inconsistent) state of renewable energy expansion in Germany have resulted not only in geographically different impacts from various undesirable developments (e.g. the overproduction of maize for biogas and the sense that wind farms are a blight on the landscape), but in regional disparities (▷ *Disparities, spatial*) as well as economic 'winner and loser regions'.

When looking at the installed capacities of various renewable energy technologies (see Fig. 7), it is initially not surprising that larger non-city states, such as Bavaria, Lower Saxony, North Rhine-Westphalia and Brandenburg, are among the frontrunners. What is interesting, however, are the significant differences in the distribution of the installed capacities in a technological comparison. In this connection, physical-geography features are crucial: for wind power, the wind conditions in the north (Schleswig-Holstein) and, for converting biogas into electricity, the importance of agriculture (Lower Saxony, Bavaria). Accordingly, the development of wind energy use in the southern federal states of Bavaria and Baden-Württemberg lags far behind that of the eastern ones, especially regarding the installed capacity per thousand residents. In parallel, the expansion of photovoltaics in the north is much less notable than in the south, which is not only attributable to fewer hours of sunlight, but also the ownership structures in the housing sector (home ownership vs. renters) as well as access to credit and other forms of financing. When biogas is converted to electricity, the agricultural structure also has a significant influence (the size of the farms or the method of cultivation, for example).

Renewable energies are associated with diverse economic advantages, both due to the operation of the plants themselves and through new industries. Through the disbursements under the Renewable Energy Act directly associated with the plant operations, in 2013 around €4.7 billion went to Bavaria alone, €3.1 billion went to Lower Saxony, €2.2 billion went to Baden-Württemberg, and €2.0 billion went to North Rhine-Westphalia (see Table 2). However, not every federal state with a large number of renewable energy plants benefitted equally from this. The disbursements are offset by the EEG levy paid by consumers (except for the fee-exempt, large electricity-consuming industries; see Fig. 7). When netted, a few of the less densely populated non-city states had a considerable overall influx of capital through the payments resulting from the Renewable Energy Act regulations. In contrast, the city states and more industrialised non-city states such as North Rhine-Westphalia, Baden-Württemberg, and Hesse show increasingly negative balances.

Figure 7: Spatial distribution of the installed capacities of power plants subsidised under the Renewable Energy Act in Germany in 2013 and the balances of the associated payment flows from 2010 to 2014 by federal state



Source: The authors, based on data from the Association of Energy and Water Industries *(BDEW 2015)*

Table 2: Key economic figures of the renewable energy sector by federal state

	Renewable Energy Act Disbursements[1] (in € million, 2013)	Gross employment (2013)	Research expenditure[2] (in € million, 2013)
Baden-Württemberg	2,150	40,540	12.90
Bavaria	4,733	60,540	20.60
Berlin	32	6,070	0.05
Brandenburg	1,388	17,580	4.40
Bremen	33	5,510	2.80
Hamburg	28	9,010	0.30
Hesse	734	20,160	1.90
Mecklenburg-Western Pomerania	817	14,980	1.00
Lower Saxony	3,130	55,200	23.20
North Rhine-Westphalia	2,005	50,330	9.70
Rhineland-Palatinate	801	12,610	0.20
Saarland	123	2,650	—
Saxony	680	16,400	3.10
Saxony-Anhalt	1,023	24,320	2.80
Schleswig-Holstein	1,320	15,740	0.70
Thuringia	519	11,460	1.10
Total	19,516	363,100	84.75

[1] Reported by the distribution grid operators
[2] For renewable energies in general, biomass, geothermal, PV and wind power

Source: The authors, based on data from PTJ 2013; Lehr/Edler/O'Sullivan et al. 2015; BDEW 2015

Although the geography of the payment flows under the Renewable Energy Act is heterogenous, the old federal states benefit the most on the labour market from the expansion of renewable energies (see Table 2). Thus, of an estimated 360,000 new jobs in the renewable energy sectors across Germany (as of 2013), more than half are concentrated in Bavaria, Lower Saxony, North Rhine-Westphalia, and Baden-Württemberg (cf. Lehr/Edler/O'Sullivan et al. 2015). Those jobs are found both in new firms, e.g. plant manufacturers or specialised service providers (in the areas of project planning and logistics, among others) and in established firms, such as those in the ▷ *Energy industry*, which are increasingly discovering renewable energy as a new business area for themselves.

On the other hand, the 'loser regions' are the east German federal states, which accommodate a large part of the renewable power plants, but the profits are mainly skimmed off by external parties (see Table 2). In 2013, for example, the six east German federal states combined received €4.5 billion in disbursements under the Renewable Energy Act, but this was still less than that of Bavaria, which benefits particularly from the high feed-in remunerations for PV installations. Since electricity consumption remains relatively low, however, the new federal states mostly show a net inflow of funds under the Renewable Energy Act (see Fig. 7). And the relatively high number of jobs (approx. 90,000, around one-fourth of the total of 363,100) should be viewed as relative, since production sites of well-known renewable energy companies, such as those in the wind industry (Enercon, Nordex, Vestas), are indeed located in east Germany, but are mostly used only as 'extended workbenches'. In contrast, headquarter functions are bundled in west Germany, e.g. in Hamburg's ▷ *Metropolitan region* in the case of the wind industry. This is also reflected in higher research subsidies, which the respective federal states invest in researching diverse renewable energy technologies. The frontrunners here are the federal states of Lower Saxony (€23.2 million), Bavaria (€20.6 million), Baden-Württemberg (€12.9 million) and North Rhine-Westphalia (€9.7 million) (see Table 2). Overall, the east German federal states remain clearly behind the west German ones; this also applies to the east German 'frontrunner' of Brandenburg, where the subsidy (€4.4 million) lies far below that of the west German federal states named here.

4 Financing, investor groups, and the significant role played by civic energy

In addition to the regional perspective on profiteers of the energy transition, a look at the investors is also interesting, since financing renewable energies requires large sums of capital. For Germany's electricity sector alone, the required capital as calculated by Kemfert and Schäfer (2012: 4) is more than €200 billion for the period 2010–2020 plus more than €550 billion for 2021–2050 (electricity and heat). Raising those sums requires private investors and the appropriate institutional conditions. The existing subsidy mechanisms, above all guaranteed feed-in remunerations, have led to a great diversity of investors in Germany. To that end, three main types can be differentiated that provide capital as owners of renewable energy projects (cf. Wüstenhagen/Menichetti 2012). These include (1) financial investors (banks, institutional investors), (2) nonfinancial companies, mainly energy providers and other strategic investors (whose core business is closely related to electricity generation, such as project developers or plant manufacturers), and (3) private individuals, i.e. citizens (including farmers). Fixed feed-in remunerations are especially important to engage the third group, which makes investment risks more calculable and therefore more attractive for private investors (cf. Walker 2008; Nolden 2013).

While energy providers are by far the most important group of investors in generating energy from fossil fuels and nuclear, renewable energy plants have a fundamentally different ownership structure. Trend:research and Leuphana University Lüneburg (2013) have shown that in Germany in 2013 around 46% of renewable energy capacity lay in the hands of private individuals and farmers, while financial investors and energy providers each had around 12% – even less than that of project developers (14%). To that end, collective forms of ownership (such as cooperatives, associations, GbR, GmbH & Co KGs) bundle almost half the equity capital provided by private individuals in Germany, which is largely invested regionally.

In particular, the rapid development of the mostly locally oriented energy cooperatives should be emphasised in this context. The crucial role of civic energy is seen as an important factor for the success of the energy transition: the more the public participates in the decision-making process, the more acceptance and political support new renewable energy projects will have (cf. Walker 2008; Trend:research/Leuphana University Lüneburg 2013; Itten/Mono 2014; Leuphana University Lüneburg/Nestle 2014). Furthermore, positive regional economic effects, and financial advantages for the municipality or participating individuals, are additional factors that increase support for renewable energy and can counter NIMBY (not in my backyard) attitudes to some extent (Yildiz/Rommel/Debor et al. 2015).

Because of growing capital needs (due in part to the increasing plant and project sizes), however, financing renewable energy plants has recently been increasingly assumed by (large) energy providers, major banks and institutional investors, as well as capital market instruments (cf. Mathews/Kidney/Mallon et al. 2010; *BdB* [Association of German Banks] 2012; DAI 2013; Klagge/Anz 2014). This results in restrictions due to stricter financial market rules or the difficult financial situation of many energy providers. However, the expansion of the tendering process set forth in the new Renewable Energy Act 2.0, the obligation of direct marketing for new renewable power plants as a rule and the corresponding successive phasing-outing of the guaranteed feed-in remunerations favour these stakeholders and disadvantage small and less financially strong stakeholders which are regionally oriented. Against this background, an expansion of renewable energy that is more strongly oriented towards the centralised models of the fossil fuel and nuclear energy industry can be expected, both regarding the participating groups of investors and the project sizes and structure of project locations.

5 Conventional energy providers and their renewable energy strategies in flux

The conventional energy industry, primarily the four large energy providers (Eon, RWE, Vattenfall, EnBW), are constantly developing new business areas, also in renewable energies. However, their investments are mainly in capital-intensive projects such as large offshore wind farms, although this mostly happens abroad (e.g. in the United Kingdom; cf. GWEC 2014). Energy providers are thus attempting to play a role in expanding renewable energies, which they have been fighting for years, and to actively shape the transformation of the energy system. They have been forced to this turnaround because their traditional business areas — nuclear and fossil fuel-based generation of electricity and heat, as well as grid operations – have been exposed to fundamentally new (market) challenges in Germany. Through the (future) expansion of renewable energies, their market shares in electricity generation dwindle in favour of new competitors known as IPPs (independent power producers). Even grid operation will be made obsolete as a business area due to liberalisation, mainly because generating electricity and operating the grid have become financially separate items on the balance sheet or separate parts of the corporation (unbundling) as a result of the new design of the electricity market at present, i.e. the regulatory and other structures which shape and organise the electricity market.

In the spot market (also the energy-only market), which handles only short-term, actual electricity generation, high percentages of renewable energy generation mean that many fossil fuel plants are unprofitable to operate – especially gas, but also pumped-storage power plants. However, due to their high compatibility with renewable energies (short startup times, flexibility, storage, low CO_2), those very plants are especially in demand whenever grid stability and the balancing out of peak demand in consumption are concerned. To compensate for the high marginal or operating costs of gas power plants with an ever smaller utilisation rate in the expected competition between the technologies (merit-order effect), a ‘capacity premium’ is under discussion. This means that not only will the kilowatt hours generated be remunerated, but making generating capacity available will also be compensated. With the Electricity Market Act *(Gesetz zur Weiterentwicklung des Strommarktes, Strommarktgesetz)* (*BGBl*. 2016 I, 1786) and the Act on the Digitisation of the Energy Transition *(Gesetz zur Digitalisierung der Energiewende)* (*BGBl*. 2016 I, 2034), both adopted in the summer of 2016, the transition to the ‘electricity market 2.0’ continued to take shape. The electricity market 2.0 clearly promotes the separation of the energy market as the ‘energy-only market’ and handling the required reserve capacities. Thus, the flexibility of the consumer side becomes paramount; for example, through load management and new storage, but also through a national shift to intelligent measuring systems in the form of *smart meters* or *smart grids*. The way to deal with capacity reserves of presumably 2 GW should be the subject of an ordinance. In the first draft of the Ordinance on Regulating the Procedure for Procuring, Using, and Billing a Capacity Reserve *[Verordnung zur Regelung des Verfahrens der Beschaffung, des Einsatzes und der Abrechnung einer Kapazitätsreserve, KapResV]* of 1 November 2016, both the remuneration and the volume of the reserve capacity was discussed, which in any case should be reviewed and adjusted annually. Whether the conventional energy industry, which has invested extensively in (gas) reserve power plants in recent years, is threatened by losses or *sunk costs* due to the separate billing thus remains to be seen.

An additional group of stakeholders of the conventional energy industry which have failed to react sufficiently promptly to the expansion of renewable energies are the public utilities and regional suppliers, i.e. energy providers in which the public authorities participate (cf. Brocke 2012). However, in recent years they have recorded growing capacities for and percentages of electricity generation, especially in the areas of biogas and onshore wind (cf. Trend:research/KNI 2011), and could become key stakeholders in the energy transition, even in light of the regulatory changes (key word: Renewable Energy Act 2.0) (cf. Feudel 2013; Sauthoff/Schön 2010; EY 2014). This is because as experienced, locally anchored stakeholders, they have special advantages in competition with large energy providers, new competitors such as IPPs, and investors who are generally from outside the region: proximity to customers, credibility, and know-how about decentralised energy systems (cf. Berlo/Wagner 2011; Klagge/Brocke 2013). In this context, new organisational forms play an important role – such as intra-firm cross-sectoral collaboration or external cooperation with local partners (energy cooperatives, savings banks) and with other public utilities (e.g. Trianel as a horizontal network) – in bundling resources and minimising investment and planing risks (cf. Leckebusch 2011; Staab 2011; Servatius 2012; *VKU* [Association of Local Utilities]/*DSGV* [Savings Banks Finance Group] 2012; Feudel 2013; EY 2014). Moreover, their sound knowledge of the region and their long-term relationships with involved and concerned local stakeholders (e.g. from municipal politics, the regional economy, or the population, including customers) could be especially valuable in the planning process or to avoid or alleviate potential land-use conflicts and create local acceptance for the expansion of renewable energies. This can become more important in the future when tapping into the unused decentralised generation potential in Germany while dealing with an increasing scarcity of land and the problems of 'acceptance weariness' and NIMBY issues. However, public utilities and regional suppliers will be able to take on this increasingly important role only if they become more open to the new market conditions.

6 Challenges in the interplay between spatial development, stakeholder constellations and planning

The expansion of renewable energies, the changes in the energy markets (the electricity, heat, and transport markets) and the energy transition in general will be defined and determined in the interplay between various spatial developments and land-use conflicts. To that end, the challenges that result from the increasingly complex constellations of interests and stakeholders, especially between the state and policymakers on the one hand and the energy industry on the other, are especially important. Within the conventional energy industry itself, an enormous range of interests and strategies are evident, and these are influenced by various interrelationships with each other and with public stakeholders. Thus, many public utilities and regional suppliers have close connections with municipal public stakeholders. At the same time, there are some highly complex participation and relationship structures between them and the large energy providers that have grown over time, through which strategic decisions are often not made independently. The new stakeholders of the energy industry are not only the competitors of conventional energy providers but their potential partners as well. Whereas the conventional energy providers were relatively late and slow to participate in expanding renewable energies, the liberalisation of the energy industry constituted the basis for the new stakeholders of the energy industry being able to enter the energy market in the first place and to establish competitive stakeholder structures. These include mostly locally oriented IPPs, electricity traders, project developers and specialised service providers, and not least the people, who have made considerable contributions to the dynamic development of renewable energies, both individually and jointly (above all in cooperatives and GmbH & Co KGs).

The stakeholders in the energy industry are also confronted by a number of different stakeholders on the public side, which – especially between different levels – sometimes act in an uncoordinated manner, but sometimes also (deliberately) against each other. Competencies and responsibilities are highly distributed in Germany along with the previously explained duality of the governance structures, in which the financial/economic decisions are made on a national level and the responsibilities and processes of planning are regulated on the state and local levels. The lack of coordination of decisions, measures, and implementation strategies by the participating ministries, state chancelleries and administrations is reflected in the fact that a few federal states formulate considerably higher renewable energy expansion targets than the federal requirements set forth in the Renewable Energy Act (cf. Jonck/Hodsman 2012). Furthermore, there is hardly any coordination between the federal states, hence planning requirements and processes as well as the general planning standards for expanding renewable energy plants vary from state to state. This also affects the question of the distribution of responsibilities and competencies between the federal state, local authorities and government region, as well as between various departments (spatial planning, building regulations, renewable energy subsidies, environmental protection programmes, etc.).

As a result, the intervention and steering opportunities available to spatial planning authorities vary considerably, and not only between the federal states, but also depending on the renewable energy technology used. For wind power planning in particular, proven planning and steering instruments are available in many federal states: in many locations, federal state spatial planning provides for general requirements (e.g. on the special importance of wind power) and provisions on concentration planning, and can even codify certain allocations of land (e.g. the state chancellery of NRW 2013: 130). Regional planning designates suitable areas for development or priority areas (▷ *Priority area, reserve area and suitable area for development*) that (can) exclude an expansion in other locations or other spatially relevant uses in the area (cf. Liebrenz 2013; Thom 2013). In the area of bio and solar energy, on the other hand, regional planning has clear limits. For regional planning to be able to address such planning and projects in the first place, evidence of ▷ *Spatial impact* must be provided for each individual project (this is the case if PV ground-mounted installations are involved, for example). Otherwise, solar installations and most biogas power plants are subject only to the steering effect of local authority or ▷ *Urban land-use planning* (cf. Arbach/Klagge/Wotha 2013; Wotha 2013). Furthermore, against the background of the regional winner/loser allocations, the further development of multilevel governance, including coordination between the federal states, will play an important role in the future of renewable energies and the energy industry in general (cf. Klagge/Arbach/Franck et al. 2013).

Besides the complex stakeholder constellations, there are additional challenges in the interplay between technology (innovation, technological changes, physical infrastructure and artefacts) and society. This essentially involves a society's tolerance for further land take or the increasing visibility of renewable energy technologies in the landscapes of some regions as more renewable power plants are constructed. The costs of the energy transition must also be mentioned, which are mostly allocated to households and small firms while energy-intensive industries and large-scale consumers can take advantage of exemptions. The Renewable Energy Act 2.0 is the legislature's temporary answer to the question of how an additional increase in electricity prices can be regulated or restricted, to limit, for example, the burden placed on low-income households due to rising energy costs. Not least, the international dimension of the energy transition – and here in particular the cross-border integration of the energy markets in Europe (common internal energy market or *energy union*) and the connection with global climate policy – represents a further challenge that will become ever more significant in the future.

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