Ressourcen
Politik

Policy Paper

The Nexus between Resource Efficiency Policy and the Energiewende in Germany

Synergies and conflicts

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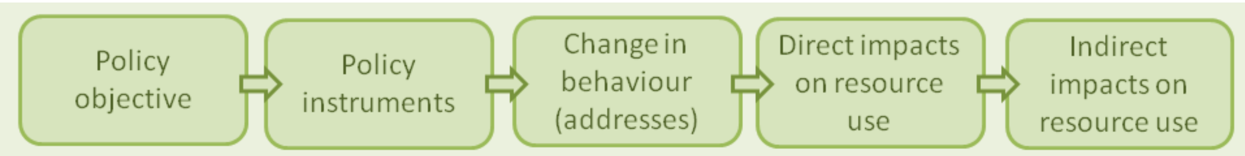
Content

1. The nexus between resource efficiency and Energiewende

Is it possible to pursue the goals of the Energiewende and enhance resource efficiency at the same time? The public debate seems to focus on conflicts between the two policy fields. A frequently mentioned example is the additional material demand from the insulation of buildings which seems to contradict the ultimate goal of resource efficiency. On the other hand it is also argued that the reduction of overall material use leads to less energy demand for mining, processing and transport of raw material – making a case for the compatibility of both policy fields.

When examining interactions, i.e. synergies and conflicts between the goals of two policy fields, it is necessary to take not only policy instruments but also behavioural changes of its addressees into consideration. Ultimately, behavioural changes lead to changing patterns in the use of natural resources and cause either synergies or trade-offs. Hence, the causal chains behind policy goals – instruments adopted, resulting behavioural changes and their impacts on natural resources – have to be taken into account for the analysis (Guske, 2013; Wolff, Heyen, Jacob, & Guske, 2013).

Schematic diagram of a causal chain



We applied this approach to assess interactions between the goals of the German Energiewende and the goals of resource efficiency policies (Werland et al., 2014). The analysis is based on an extensive review of studies and on the expertise of the authors. On this basis we identified and validated interactions between the two policy fields; but we also found it would require more in-depth analysis to quantify these effects in most cases. With the screening method applied, it was also not possible to account for all conceivable indirect and induced effects including second round effects and rebound effects – which have not yet been adequately addressed in research.

What are the policy objectives under consideration? The Energiewende aims at reducing the demand for energy, avoiding greenhouse gas emissions and phasing fossil and nuclear fuels. Approaches are inter alia to increase energy efficiency of buildings and products, to promote renewable energies and to advance e-mobility. Resource efficiency policy, as it is outlined in the German Resource Efficiency Programm (ProgRess), aims at increasing the efficiency of material use and thereby lessening not only the import dependency of the German economy but also the environmental impacts of resource use. Measures are proposed in three key areas along the value chain: (1) increasing resource efficiency in production processes (including substitution of material), (2) furthering resource efficient consumption and (3) promoting a resource efficient circular economy. ProgRess focuses on abiotic, non-energetic resources, like ores and metals, industrial minerals, construction materials, critical raw materials, as well as the material use of biotic and fossil resources.

2. Key findings

2.1. Impacts of the Energiewende on resource efficiency policy

Overall, the Energiewende induces a shift in the material basis of energy production from fossil fuels and nuclear towards biomass, wind, water, geothermal and solar energy. Both fossil fuels and renewable energies have considerable albeit different impacts on natural systems and different characteristics of resource input along their life cycles – what makes a direct comparison of the energy systems difficult. Most studies, however, claim that the goals of the Energiewende contribute to a more efficient use of natural material resources (Becker, 2014; Hanke, Soukup, Viebahn, & Fischedick, 2010).

Increasing energy efficiency

One pillar of the Energiewende is fostering the efficient use of energy. About 40 per cent of the energy use in Germany is related to building and housing, mainly for heating, but also for electricity (Rohn, Pastewski, & Lettenmeier, 2010). Measures to improve the energy efficiency of buildings include mandatory energy performance certificates, energy counselling, energy standards for new buildings or the promotion of energetic refurbishment of existing buildings. The latter two can be expected to cause an additional demand for insulating material (based on crude oil, minerals or biomass) while reducing the demand for oil and gas that are commonly used for heating in Germany. While a range of studies forecast a decline of overall resource use (both energetic and material use combined) from the insulation of buildings in the long run, one main issue remains the recycling and deposit of insulation material (Kolb, 2014).

Another critical field is the fuel consumption of new cars with minimum standards laid down by the European Union. One path to reduce fuel consumption is light weight construction (Ellenrieder, Gänsicke, Goede, & Herrmann, 2013; Friedrich & Krishnamoorthy, 2013; VDI ZRE, 2014). Implications for material use are the substitution of steel by aluminium, magnesium, titanium or fibre-reinforced composites. From a resource efficiency policy perspective the recycling of such composites is technically more demanding and more energy intensive than the recycling of metals (Eickenbusch & Krauss, 2014). Other approaches to light weight engineering are the use of high strength steels or tailored blanks, i.e. semi-finished metal sheets with varying thicknesses and material properties. Angerer et al., for example, expect a relative decoupling of material use and vehicle production due to lightweight engineering. Since the number of vehicles produced is assumed to increase in the coming decades, however, they still estimate a “moderate increase” in the demand for steel for the production of automobiles (Angerer et al., 2009). On the other hand lightweight engineering requires high quality raw materials and recycled steel most often is not suitable for these purposes. This might in turn increase the demand for iron ores (Angerer et al., 2009). Moreover, many substitutes have bigger ‘ecological rucksacks’ that again might increase the environmental impacts of lightweight engineering (Wuppertal Institut für Klima Umwelt Energie, 2014).

Promoting renewable energies and its infrastructures

Renewable energies comprise water power, wind, geothermal power, and biomass. The development of renewable energies on the one hand aims at reducing the use of fossil and nuclear fuels. On the other hand, it is often stressed that renewable energies and the rebuilding of energy infrastructure require huge amounts of critical raw materials such as copper, gold, neodymium, or silicon (Angerer et al., 2009;

Behrendt, Erdmann, Marwede, & Caporal, 2010; Hertwich et al., 2014; Kleijn, van der Voet, Kramer, van Oers, & van der Giesen, 2011). Such comparisons are misleading in so far as the technologies show different characteristics of material requirements throughout their life cycle stages. Generally speaking, the most resource intensive parts of the life cycle of renewable energies – with the exception of biomass – are the production and installation of the power generation equipment while fossil-fuelled plants and nuclear power stations require continuous input of fuels during their operation. Taking the whole life cycle into consideration it can be argued that a potential additional consumption of material for the construction will be over-compensated during the operation stage (Hertwich et al., 2014; Kleijn et al., 2011).

The use of biomass is a special case of renewable energies. Same as fossil fuels and nuclear, it depends on a steady input of material during its operation. Studies highlighted potentially high impacts on land use, soil and water both in Germany and worldwide and an increasing use of nitrogen and phosphorous (Bringezu, O'Brien, & Schütz, 2012; Bringezu & Schütz, 2008; Dehoust et al., 2014; UNEP, 2014). The global nitrogen cycle was identified as one critical earth system process by Rockström et al. (Rockström et al., 2009); phosphorous is considered a 'critical raw material' with high supply risk (European Commission, 2014). Environmental impacts of the use of biomass were found to vary greatly according to plants, farming methods, regional origin and usage systems – with cascade use of biomass being proposed as one sustainable approach (Bringezu et al., 2012; Carus et al., 2014; Hermeling & Wölfing, 2011). Globally, the demand for food is growing faster than the yield increase of cropping systems. As a consequence, cropland will be expanded at the expense of grassland, savannahs and forests, mainly in the tropics. All additional demand for non-food crops such as for biofuels or biogas will increase the pressure on this land use change (UNEP 2014). If policy were to put first priority on food, any support or mandatory requirements to use biofuels based on cropland would need to be phased out. The example of biofuels and bioenergy shows that the Energiewende needs to be further developed to consider also conditions of sustainable resource use.

Advancing E-mobility

The substitution of fossil-fuelled vehicles by electric vehicles changes the raw material base of mobility. While the consumption of oil and gas for transport will be reduced, demand for electricity will rise. The effect on the consumption of primary fuels depends of the electricity mix and the efficiency level of power generation. The production of electric vehicles requires critical materials such as neodymium or lithium (Angerer et al., 2009; Buchert, 2011; Cleanenergy Project, 2013; Erdmann, Behrendt, & Feil, 2011; Exner, Lauk, & Schriefl, 2013; Fraunhofer ISI, 2012; Schrode, Burger, Eckermann, Berg, & Thiele, 2010; Siemens, 2013). Thus, although e-mobility evidently is compatible with the use of renewable energies, there is no conclusive evidence that fostering e-mobility automatically reduces the material consumption for transport purposes and its environmental impact (Viebahn et al., 2014).

2.2. Impacts of resource efficiency policy on the Energiewende

Increasing resource efficiency in production processes & substitution of materials

The optimization of production processes and/or the use of innovative materials in products are technical means to enhance resource efficiency. There are several instruments in place such as resource efficiency consulting for businesses or environmental management systems. These policy instruments aim at reducing the use of material, e.g. via reduction of cuttings, optimizing the thickness of material, using standardized components or modular systems and at substituting critical or environmental harmful materials. Optimizing production processes can help to reduce material use significantly.

According to the Baden-Württemberg Ministry of Economic Affairs waste from punching processes can make up to 80% of material used (Wirtschaftsministerium Baden-Württemberg 2010: 63); in automobile manufacturing 60% of the metal sheets used end up as production waste (Frauenhofer Gesellschaft, 2012: 12). Avoiding waste in production processes is thus synergetic with the aims of the Energiewende, as energy used for the production and recycling of surplus material is saved. According to the International Resource Panel, the ferrous and non-ferrous metals industry is responsible for about one fifth of global industrial energy demand and the primary production of metals requires roughly 8 per cent of global energy consumption (UNEP, 2013a). One can conclude that overall reduction of material use in production processes does have positive impacts on all other natural resources.

Also in respect of substituting materials – mostly abiotic materials, which are used in the building sector, with biotic materials (Carus et al. 2014: 54) –impacts are overall synergetic with the aims of the Energiewende. Cement and steel production are both very energy intensive and the substitution of these materials with biotic ones leads to a reduction of the use of energy resources (Bribián, Capilla, & Usón, 2011; Buchanana & Levine, 1999; Goverse, Hekkert, Groenewegen, Worrell, & Smits, 2001; Sathre/Gustavsson 2009). Generally, when assessing the environmental performance of biomass as a substitute for abiotic materials, it is important to take the whole life cycle into account, including e.g. agricultural practices and transport distances (Dias & Arroja, 2012; Rettenmaier et al., 2014: 56). However, conflicts with the Energiewende can arise, since biomass is a limited resource and is used for energy production as well (Bringezu et al., 2008). Some studies also forecast a gap in wood availability due to its energetic use, which shows once more that substitution with biomass must be carefully assessed (Ponitka, Lenz, & Thrän, 2011). While a substitution of abiotic material with biomass does reduce energy use, its impacts on the resources soil, land, water, air and biodiversity must also be taken into account (Weiss et al., 2012). For example, increased use of biomass can have indirect impacts on soil and water quality (fertilizers) and can lead to land use change which in return effects GHG emissions and decreases the capacity of soil to function as a CO2 reservoir.

Furthering resource efficient consumption

Resource efficient consumption aims at satisfying consumer needs with the least possible input of material. This comprises technical resource efficiency innovations as well as strategies of reducing overall product consumption or intensifying product-use (e.g. sharing of products, extension of use period). Some of the policy instruments and measures are: raising awareness, introducing certification schemes for resources or using public procurement (Deutsche Bundesregierung, 2012a). It is difficult, however, to assess behavioural change resulting from these instruments, as it highly depends on individual preferences and behaviour. As the example of car-sharing shows, it can both have negative (car sharing as addition to private car) as well as positive impacts on resource use (substitution of private cars) (Scholl, Gossen, Grubbe, & Brumbauer, 2013). Regarding the use of second hand products or using products for a longer period, it can be assumed that it is synergetic with the reduction of energy use. An overall decrease of primary resource use generally reduces the demand for fossil fuels for the production and transportation of material and products – with the potential exception of energy using products where gains in efficiency may outweigh the energy saved from extending the product's life time. Moreover, avoiding the extraction, processing and disposal of material has positive impacts on other natural resources, such as land, soil, water, air and biodiversity.

Promoting a circular economy

There are various regulations for enhancing the circular economy, e.g. producer responsibility, take-back obligations or the WEEE-directive on exporting e-waste to other countries, to name but a few. Although recycling can be energy intensive, it is still more energy efficient than mining and processing primary materials in most cases (UNEP, 2013b). The potentials for GHG-emission reduction through circular economy have been calculated for 2030 and 2050 with 31 million Mg CO_2eq – this is 20 percent of the emissions of transport in Germany in 2011 (Dehoust et al., 2014, p. 53). One notable exception is recycling of concrete which is almost as energy intensive as the production of concrete from primary material, because the highest share of energy consumption is used for the production of cement (which is not affected), and the crushing of old concrete also requires energy. From a resource efficiency perspective recycling of concrete makes sense for the protection of local sand and gravel (Heyn and Mettke 2010: 79).

Overall, the studies which have been analysed indicated synergies not only between the Energiewende and the circular economy, but also between circular economy and the protection of soil/land, water, air and biodiversity.

3. Conclusions

Efforts to increase resource efficiency have been shown to contribute to the goals of the Energiewende. Put simply, the less material is extracted, processed, transported, and used, the less energy is needed. Impacts of the Energiewende on resource efficiency are not so clear. Although most studies claim that additional demand for material e.g. for insulating houses, light weight engineering or the installation of renewable energies are over-compensated during their utilization phase, the public debate still seems biased: necessary investments in the initial life cycle stages often are overestimated and savings during latter stages neglected. This applies both to costs and to resource consumption of the Energiewende. The main issue when assessing the impacts of the Energiewende on the use of resources is that we have to compare products and systems with different material composition and different input of resources during different stages of their lifetime. Overall, our analysis of studies that address interactions between aspects of the Energiewende and resource policies (Werland et al., 2014) has shown that synergies between the two policy fields clearly outweigh conflicts if (1) whole life cycles are assessed and (2) also indirect effects of raw material use on soil, land, water, air and biodiversity are considered. A common set of indicators for measuring and comparing resource consumption both for energetic and material use of resources might help overcoming this bias. The four footprints (material, land, water, and carbon) can be a candidates for this.

The literature analysis has also shown that the proper use of biomass is crucial in both policy fields, and an uncontrolled rise of biomass use is prone to increase problem shifts. The interactions between resource policies and the Energiewende should get closer attention with regard to biomass use. Understanding these interactions and developing approaches that enhance synergies and avoid trade-offs seems one central issue for the success of both policies.

A quantification of the synergies and trade-offs between resource policies and the Energiewende would require more in-depth analysis and modelling. Appropriate tools towards this end are available.

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