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The Role of Law in Transformative Environmental Policies—A Case Study of "Timber in Buildings Construction in Germany"

Grit Ludwig

Department of Environmental and Planning Law, Helmholtz Centre for Environmental Research, Permoserstraße 15, 04318 Leipzig, Germany; grit.ludwig@ufz.de; Tel.: +49-341-235-1875

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Abstract: Over the last decades, environmental law has significantly contributed to limiting the environmental impacts of our mode of living. Yet environmental problems still prevail and are strongly linked to our production and consumption systems. Therefore, the current challenges must be tackled with a systemic approach. The concept of transformative environmental policy identifies approaches for policymakers to interfere in socio-economic systems in order to give them a more sustainable structure. This article seeks to identify the contributions that law can make to a transformation towards sustainability. For illustrative purposes, I point out the concrete steps in a case study on increasing the use of timber in buildings construction in Germany. I argue that law plays a role in all three phases of a transformation/transition. The legal framework must enable innovations and experiments in the first transformation phase, come up with restricting regulations for old non-sustainable structures in the second phase, and in the third phase provide course stability for the new system. I conclude that the concept of transformative environmental policy helps to design adaptations of the legal framework in order to transform socio-economic and socio-technical systems towards more sustainability.

Keywords: role of law; transformation; transition; transformative environmental policy; buildings construction; timber construction; sustainable building materials

1. Introduction

Although environmental policies have delivered substantial benefits for the environment and people's well-being in the past, our economies (still) face persistent environmental problems. The challenges are systemic, in the sense that they are tied to our prevailing mode of living and the economic, technological, and social systems caused by it [1,2]. Incremental approaches are no longer sufficient for tackling these challenges and the research on transformation/transition aims to fill this gap. 'Transformation' and 'transition' refer to profound and enduring systemic changes of socio-technical and socio-economic systems which are characterized by co-evolutionary developments within and between subsystems of society. Socio-technical and socio-economic systems are specific configurations of technologies, products, infrastructures, markets, social practices, related institutions, and cultural values which serve particular needs of society [3]. Transformations to sustainability change the system elements in such a way that sustainable development concerns are prioritized [4]. So far, there is no example of a completed transformation to sustainability, but in the case of the German energy transition a transformation is at least under way [5]. Beyond this, the food, transport, and housing systems [1] but also topics like 'urban land use' or 'materials and material flows' [6] have been identified as potential transformational fields. Apart from these comprehensive transformational fields, systemic changes can also occur in subsystems. The aim of this study is to give an insight into

the contribution of law to a transition towards more sustainability. Law alone is not able to trigger and steer a transformation to sustainability, but together with economics, planning, political and informational instruments it has enormous potential to do so. To make the role of law in transitions tangible, the article illustrates the necessity of particular legal interventions in a case study regarding the system for building materials in buildings construction, especially the increase in the use of timber. After an introduction to the case study (2.), I will describe the concept of Transformative Environmental Policy (TEP concept) as a framework for agency in transformations/transitions (3.). In Section 4, I will depict the role of law in the application of the TEP concept in the case study "Building materials in buildings construction in Germany".

2. Case Study "Building Materials in Buildings Construction in Germany"

The case study on increasing the share of timber as sustainable building material in the German construction sector has been selected as an example of a transition towards greater sustainability for various reasons: First, "building materials" has been categorized as part of the transformative action field 'materials and material flows' [6] (p. 172 f.). Second, the system of building materials in the German building construction sector is not too complex and does not touch upon too many fields of law. The case study touches upon various sustainability issues, from the saving of CO_2 emissions to the avoidance of environmental damages caused by the extraction of gravel and sand as additives for concrete. It illustrates the importance of thinking in systems for solving today's environmental problems. Because timber does not have a major potential in civil engineering, the case study concentrates on buildings construction. As the objective of this study to illustrate the role of law in a transition, a detailed picture of the law regarding the mentioned system cannot be given here, but only a rough overview of the necessary alterations in the legal framework over time.

The legal framework for the transformative action field "building materials" consists of regulations in various fields of law. It comprises the law which predominantly refers to the "old" system, especially conventional building products in the construction phase, as well as the law which mainly regulates the "new" system, in particular timber as a construction material, and also the transformation phase. This section provides an introduction to the case study. It depicts the status quo of building materials in the buildings construction sector in Germany as a socio-technical system (Section 2.1) and creates a vision for the use of sustainable building materials (Section 2.2). Beyond that, this section reflects upon the challenges of such a transition (Section 2.3).

2.1. Building Materials in Building Construction—Status Quo

In order to understand which legal rules are relevant in the case study, this section gives a picture of the situation regarding building materials in the German construction sector at present. Here, we already have a share of timber of about 15% at present. This is calculated based on the ratio of the number of building permits with timber as the predominant building material to the total number of building permits [7] (p. 137). In 2014, around 16% of single-family houses in Germany were built with wood (according to gross building volume), 7% of the non-residential buildings, especially in the agricultural sector, and only 2% of multi-family houses [8]. By comparison, Switzerland and Austria—by applying different policy instruments—have reached a share of timber construction of 30% [9]. The lion's share of building materials in the German buildings construction sector is made up of conventional building materials like concrete, aluminum, and steel (85%). These materials have a big environmental footprint: First, they are very energy intensive in production [10] and their greenhouse gas emissions (GHG emissions) should be covered by the EU emissions trading scheme (EU ETS). However, in view of low prices for emission permits, the EU ETS has only a limited impact on production costs at present [11]. Second, the construction of buildings requires large amounts of natural resources. Every year, Germany extracts around 450 to 550 million tons of gravel, sand and natural stone [12,13], most of which is used in the German construction industry. Together with Spain, France, and Italy, Germany is one of the main producers of construction minerals [14]. Based on the

absolute weight of the extracted quantities of sand, gravel, crushed stone, and limestone, the mineral sector is the most resource-intensive sector in Europe [14]. The extraction of construction minerals leads to significant land and nature consumption, often combined with adverse effects on water resources and settlements. As a result of this high consumption of primary resources and limited recycling, construction and demolition waste accounts for 54% of waste accumulation in Germany [15] (p. 62), compared to one third in Europe [16]. Recycled construction minerals account for around 10% of the construction materials applied in German buildings [17]. An obstacle to the use of secondary raw materials in the construction industry is that recycled construction materials do not always have the same performance as primary construction minerals. Therefore, clear-cut separation according to types of construction materials is crucial [18]. Beyond that, recycled construction materials are not always available in the region where they are needed [18].

2.2. A Vision for the Use of Sustainable Building Materials in the German Buildings Construction System

There are various options for using more sustainable building materials in buildings construction in Germany in the future. Examples include the reduction of the emission intensity of process-related emissions in the concrete, steel, and aluminum industry, the reduction of material consumption per service unit at the product level, or the substitution of emission intensive materials, for instance timber [6] (p. 172 ff.). Other possibilities are the use of secondary raw materials as well as the extension of the useful life of buildings. This study concentrates on increasing the share of timber as a vision for the future. As the aim of this study is to provide an insight into the contribution of law to a transition towards more sustainability, it was necessary to select a subsystem with clear-cut system frontiers, which is the case for timber. Another argument is that timber construction has been recently highlighted as a GHG-saving and resource-efficient alternative to concrete and steel [6,9,19], which makes it worth studying.

Timber has been applied in construction since the Stone Age. With new technologies it has been transformed into a modern construction material [20]. Today, timber is not only used for single- and two-family houses, but also for multi-storey buildings [19]. Timber has a relatively low weight, and is therefore suitable for adding a floor onto existing buildings. In that way it contributes to a moderate densification of cities and helps to avoid land consumption [6]. An advantage of timber is that industrial fabrication is possible [21,22]. Beyond that, timber has a lower potential for acidification, ozone production, and toxicity in comparison to functionally equivalent products made of other materials [23]. The disadvantages of timber are: it is combustible, vulnerable to fungal decay and pests, and susceptible to water damage [24]. However, technical solutions are to a large extent available today [25–28]. Regarding the useful life of buildings, the same time span is assumed for both modern timber buildings and reinforced concrete buildings, provided that they are properly maintained and serviced [29]. Another aspect is that timber construction is able to supply the lower to medium market segment [30], which is urgently needed in German cities at present [18].

From a macroeconomic perspective, one of the distinctive positive characteristics of wood as a building material is that it builds up a carbon store in the technosphere when applied in construction. Whereas by energetic use of wood the carbon stored by the tree is dissolved immediately, durable wood products prolong the storage effect [31]. Cascading use with a repeated material use of wood in the buildings construction sector and an energetic recovery at the end of the life cycle reinforces this effect [32]. Beyond that, the substitution of aluminum, steel, and concrete saves the GHG emissions that would be generated by the production of these conventional building materials. Therefore, the constitution of a carbon sink for biogenic carbon in the technosphere by material use of wood has been classified as a very effective climate protection measure [6,9,29,33]. Another effect of substituting mineral and metallic resources by wood is the reduction of pressure on the environment linked to the extraction of raw materials.

However, with an increasing demand for wood for construction, imports will be necessary and the risk of negative effects on the GHG balance, nature protection, and social aspects rises [28]. A challenge

in respect to imported timber is to secure effectively compliance with sustainability standards in logging [34]. Therefore, the guarantee of a sustainable resource base is crucial [35].

2.3. Challenges of Increasing the Share of Timber as a Construction Material in the German Buildings Construction Sector

To realize the vision of an increased share of timber as a construction material in Germany, distortions of competition with conventional construction materials need to be overcome. These include incompletely internalized environmental costs, path dependencies, information deficits, and asymmetries (for timber–concrete–composites cf. for instance [8]), as well as competition between material and energetic uses [24]. Regarding incompletely internalized environmental costs, for instance, carbon emissions of cement and metal production are covered by the EU ETS. However, in view of low prices for emission permits, the EU ETS has only limited impact. Information asymmetries exist in particular with respect to the possibilities of the use of timber and aspects of utility value, and also regarding climate protection effects and sustainability of wooden building products [36]. This leads to lower investment in environmental friendly innovations than would be required from a societal perspective [37]. Another market failure in the coordination of construction decisions are path dependencies—especially regarding multi-storey buildings. Here, experience, competencies, and well-established value chains are aligned to conventional building products, which is also true for institutional framework conditions (e.g., building law) [38].

Beyond that, competition between material and energetic uses influences the competitiveness of wood as a building material. In a free market, producers of high value applications are usually able to pay a higher price for raw materials. In respect of renewable raw materials, this usually applies to material uses [39] (p. 3). The promotion of bioenergy in recent years could have impeded a level playing field between material and energetic uses. In the year 2010, more than 50% of fresh wood in Germany went into energetic uses in households and industry [40] (p. 8). This problem is not limited to Germany, but—as a consequence of international efforts to decarbonize the energy system—a Europe-wide and worldwide challenge [41] (p. 28). However, with a change in German bioenergy policy, the demand for wood from large-scale wood firing plants diminishes and existing stocks of wood allow for an increase of material use of domestic wood in Germany [42]. The use of domestic wood should have priority in relation to wood imports in order to avoid new sustainability problems [43].

In sum, a number of significant challenges need to be tackled by legal (and other) interventions to enable a transition to the increased use of timber as a more sustainable construction material in the German buildings construction sector.

3. The TEP Concept as a Framework Describing the Possibility of Agency in Transformations/Transitions

In order to understand what contribution law can make to the governance of sustainability transitions, this section gives an overview of theories dealing with the possibilities for intervening in transformations. It describes the TEP concept applied in this study in more detail. Transformation research has focused on two strands: first, understanding past transformations and their governance, e.g., [44–46]; and second, identifying measures to trigger and influence transformations towards more sustainability, cf. [47]. This article is dedicated to the second research strand. Transformations are sparked off by the combination and interplay of different factors (technologies, institutions, and cultural practices, etc.), while the capacities of governments to plan and steer societal transformations are limited [48]. The main challenges of transformative environmental policy are the following: competing visions and objectives, complexity, interdependencies and co-evolution within and beyond systems, capacities and resources to influence transformations scattered between different actors, as well as the role of time and path-dependencies [49]. Regarding agency in transformation/transition processes, different aspects have been analyzed in the literature up to now. One of the starting points is the research in system theory on leverage points for the intervention in systems [50,51]. From a social

sciences perspective, two main approaches—the multi-level perspective (MLP) and the technological innovation systems (TIS) approach—serve as bases. The MLP differentiates three levels (niches, regimes, and landscapes) where changes take place. It emphasizes how the alignment of trajectories within levels, as well as between levels, produces transitions [3]. Building on the MLP approach, the transition management approach, developed in the Netherlands, provides a framework and set of tools for the development of transition-based governance strategies [47]. The TIS approach conceptualizes a transition as a buildup process of different technological innovation systems [52]. Related to the latter is the approach of strategic niche management. It is based on the idea of niches as incubation spaces for disruptive innovations. These are often facilitated through government interventions in practice, for instance [53].

This article focuses on another approach—the concept of transformative environmental policy (TEP). It proposes eight ways in which transformations to sustainability may be triggered and forwarded. The TEP concept was developed for application by employees of the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety [49], as well as other environmental authorities. Its focus is on the governance of transformations from a very practical point of view; two of the approaches have a strong link to law. Therefore, it seems to be an appropriate concept for achieving the aims of this study. TEP has been identified as a third option for environmental policy—complementing policies limiting harmful emissions and the overuse of natural resources on the one hand, and Environmental Policy Integration on the other [48]. The TEP concept indicated eight approaches for interventions in socio-technical and socio-economic systems in order to trigger transformations to sustainability [49]:

1. A systematic analysis of the transformational field;
2. Detection, assessment and use of societal trends;
3. Facilitation of the development of societal concepts and objectives;
4. Configuration of societal interfaces;
5. Promotion of innovations and experiments;
6. Deliberate termination of non-sustainable structures (exnovation)
7. Involvement of new actors; and
8. Time strategies.

4. The Role of Law in the Application of the TEP Concept—The Case of "Building Materials in Buildings Construction in Germany"

Transformations to sustainability have been characterized as being divided into three phases [54]. This section examines the role of law in the three phases of a transformation. After a pre-phase, which prepares interventions in the system, phase 1 focuses on the creation of dynamic and diversity, vision search, as well as the analysis and utilization of societal trends. In phase 2 the state needs to provide course stability. Innovations need to be selected and scaled, exnovations need to be organized. Phase 3 is characterized by the consolidation of the new system, in detail: [5]. In this section, I will apply the TEP approaches in the pre-phase and the three transformation phases to the case study.

4.1. Pre-phase

In elaborating transformative environmental policies, government needs to conduct a systematic analysis of the transformational field (approach 1 of the TEP concept). This includes not only an analysis of technical data, but also a thorough examination of the political, economic, and legal framework conditions. First, the fields of law relevant to the subsystem concerned, need to be identified. In the case of increased use of timber in buildings construction in Germany, the regulations for the present system, for the transformation, as well as for the future new system are relevant. The system for buildings construction in Germany is mainly characterized by steel, aluminum, and concrete as building materials, which implies the existence of specific technologies, products, infrastructures,

markets, social practices, related institutions, and cultural values. The legal framework for this "old" buildings constructions system is formed by various fields of law: the regulations on the extraction of gravel and sand for the production of concrete, rules for the fabrication of cement, steel and aluminum, building construction law, building products law etc. The legal framework for a more sustainable ("new") buildings construction system in Germany—with other actors, technologies, markets, infrastructures, etc.—comprehends all legal areas regulating the provision of sustainable—especially renewable—building products. In particular, it includes rules for the production and import of wood, its processing and utilization, the marketing or placing on the market of wood-based construction products and their re-use. These regulations form part of direct timber construction policies [21]. Beyond that, the legal frameworks for the "old" as well as the "new" systems include all regulations that affect timber construction without making specific demands on it, and which form part of indirect timber construction policies. These include circular economy law, urban planning law, building construction law, building products law, the law concerning important competing areas of the use of timber for construction, such as the energetic use of wood, etc. The systematic analysis of the transformational field does not also comprehend law, but also economic, societal, and political framework conditions, which do not form part of this study.

Beyond approach 1, approaches 2–4 of the TEP concept are also applicable in the pre-phase: (2) the detection, assessment and use of societal trends; (3) the facilitation of the development of societal concepts and objectives; (4) the configuration of societal interfaces. Approaches 2–4 do not have a closer relationship to legal aspects.

4.2. First Transformation Phase: Promotion of Diversity

In phase 1 of a transformation, promoting diversity is the main task. The initial phase of a transformation is characterized by a high density of innovation that entails alternative visions [5]. Innovative products, developed in niches, do not imply the promise of a mere improvement of the existing status quo, but of an alternative system. Once an innovation passes critical moments, e.g., a critical mass of applications has been reached, network effects are created etc., and transformation speeds up [5]. If an innovation and its diffusion change the framework conditions for another element of the given system, innovation co-evolves in different elements of a system; for the energy system [55]. In this phase, the vision of an alternative system configuration is shared by an increasing number of actors, and gains acceptance. Visions are often promoted by actors from outside the established structures, but from a governance perspective, the state needs to select one of the visions for a distinct sustainable system and adopt it as its own. The concrete vision of a sustainable system, for instance 100% renewable energies in electricity provision, should guide policy makers through the whole transformational process.

In sum, in the first transformation phase the state needs to provide niches for creativity in order to ensure that supportive institutional structures are in place for green entrepreneurs [56]. Besides other political measures, an innovation-friendly law is necessary. The role of law in pushing eco-innovations is twofold: on the one hand, restricting regulations may activate the search for innovations, for instance to reduce emissions or avoid hazardous substances [57]. On the other hand, a condition for innovation is that there are appropriate spaces for action for innovators. Generally speaking, this is the case in a free basic order. However, law also has the task of preventing risks, but the risks of "the new" are not very predictable. Here, the law of risk prevention enters the game and it may obstruct innovations in the name of other protected legal interests. Another aspect is that the legal framework in force forms an environment for innovations and it is structured around existing products and technologies. The legal framework contains framings, structural specifications, and content-related orientations, especially in respect to the protection of legal interests that may obstruct innovations [58] (p. 710 f.). Therefore, knowledge of regulation in place has been stressed to be one of the key factors for successful innovation [59]. Obstacles to innovation which could be provoked by the persistency of a legal framework designed in favor of conventional products and technologies should be prevented by

exemptions from liability rules or other regulations and option-based law. Economic instruments, like grants, tax releases, or levies play a significant role. However, it is not only law, but also political, societal, and economic conditions which enable or hamper innovations. An innovative environment also comprises subsidies for research and development, support for the provision of venture capital, and a constant alignment of the science landscape and the education system towards the facilitation of innovations [59]. In sum, innovation-friendly regulation presents chances but also risks. Incalculable or even contra-productive side-effects or windfall effects may be caused. Granting positive incentives may lead to path dependencies of once adopted enabling policies, with the risk of wasting financial resources, the failure to achieve targets, or the neglect of other public interest objectives [58] (p. 711). With respect to the TEP concept, approach 5—promotion of innovations and experiments—is applicable from a legal point of view.

Applied to the case study, the most pertinent question is whether law is open for innovations and experiments regarding timber construction in niches [22]. Existing policies and regulations for buildings construction, especially building law and building products law, were not developed with the types of houses and building methods of "greener" construction in mind [20]. These will be analyzed as follows. Because of market distortions in favor of conventional building products, instruments for the promotion of sustainable building materials are also pivotal.

4.2.1. Building Law

Building law in Germany is under the competence of the *Laender.* The building regulations of the *Laender* specify the requirements for the safety of buildings. Having been developed with conventional building materials in mind, they may have put timber-frame buildings at a disadvantage, especially regarding fire protection and stability of multi-storey buildings. Therefore, the model building code in the 2002 version significantly extended the field of application of timber construction beyond the classic single-family house or building of low height. Many *Laender* followed suit and changed their building regulations with regard to the stability of multi-storey buildings in such a way that they allowed a "material equivalence" of wood and conventional building materials. In other *Laender*, however, building regulations currently still place multi-storey timber buildings at a disadvantage in this respect. In fire protection, too, the requirements for multi-storey buildings made of wood are more difficult to meet, in detail [60–62]. Hence, the building law needs to be scanned and adapted in order to allow the development of innovations in niches as well as experiments regarding more sustainable building materials, especially timber.

4.2.2. Building Products Law

While the building regulations of the member states are responsible for the safety of the "end product construction", the EU provides the "common technical language" for construction products. Requirements for building products are set primarily by the EU Construction Products Regulation in connection with the building regulations of the *Laender*. Not only the building regulations, but also the standards have been established for conventional building materials and therefore by trend may put timber-frame buildings at a disadvantage. Moreover, standards for construction products are often complex and not very practical. Excessive standards are criticized, as are product standards which are inadequate or even contradictory. The development of standards is a lengthy affair in which representatives of the timber construction industry are only insufficiently involved. The standardization work related to timber construction must be advanced. This also requires political support measures, in detail [60].

Another aspect is that there are no requirements for buildings with regard to the sustainability of construction products, neither at EU level nor in Germany [18,24]. Therefore, pure information remains the norm. Binding sustainability requirements would help wood to yield its advantages over mineral and metallic building materials.

4.2.3. Instruments for the Promotion of Wood-Based Building Products

Because of the distortion of competition between timber and conventional building products, promotional economic instruments construct an important element in the policy mix to create a niche for timber construction in the innovation and experimentation phase. In order to paint a broader picture, this section mentions economic and informational instruments which are very important in the first transformation phase. For the creation of niches for the development of innovative products, market support programs are an essential element. Referring to timber construction, for example, the cities of Munich and Hamburg pay a bonus of 30 cent per kg for the use of wood in buildings construction [63]. Market support programs must be supplemented by informational instruments in order to overcome the lack of knowledge and reservations of building planners, consumers, building supervisory authorities, and financers [21]. The Charter for Wood 2.0 of the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMEL) comprises political statements in favor of the material use of timber which, however, still need to be underpinned by concrete support measures [31]. Significant support for timber construction, including research funding, would not least send out signals to universities to anchor modern timber construction more firmly in higher education, so that appropriate knowledge is available to future architects and building planners [21,23]. Last but not least, evaluation and certification systems play an important role in the support for sustainable construction materials [36].

Another measure to promote market entry as well as market penetration of wooden building products is green public procurement. It has long been recognized that environmental criteria can be included in the award of public contracts. Preferring wood-based building products in public procurement can help to create a niche for timber construction. Another possible measure is specifications in favor of timber construction in land-use plans, which are drawn up by the municipalities. Since the year 2011, the German Federal Building Code obliges municipalities to take account of the requirements of climate protection in urban land-use plans [64]. The most cited case of application of this regulation is the specification of areas in development land-use plans in favor of power plants which serve the production of renewable energies. However, requirements for building materials to be used are currently not possible in land-use plans. This is where the legislator should take action and allow specifications in favor of timber construction [24]. Together with the other measures mentioned this would allow timber construction to be developed further in a niche in the first transformation phase.

4.3. Second Transformation Phase: Providing Legal Certainty

After innovations have been selected and scaled, restricting regulations for old, non-sustainable structures are required in phase 2 of a transformation. Regarding the "old" products, the hitherto existing production and consumption becomes culturally stigmatized and social practices are adapted to the new system. As a result of this acceleration, existing practices, technologies, structures, and the related actors are questioned on their legitimacy and suitability to provide their services to society [5]. However, the heuristic of "creative destruction" which assumes that "old things" disappear when innovations emerge does not exist [65]. Therefore, restricting regulations for old, non-sustainable structures is required. Regarding the TEP concept, in the second transformation phase, approach 6 is applicable: exnovation and other restricting regulations for old, non-sustainable structures. Here, legal interventions are inevitable. In general, obstacles to transformative governance can arise from vested interests that control and benefit from existing system configurations or from legacies and stabilizing feedbacks that generate pathological trajectories [66]. Because of these vested interests and because the history of modernity is a history of biophysical expansion which created our imperial mode of living [2,67], the promotion of innovative products is easy in comparison to the pushing out of non-sustainable structures of the system. For instance, existing product standards may obstruct the market entry of new products, because they are tailored to the hitherto existing products. Hence, market conditions for the new products developed in phase 1 need to be stabilized. Environmental

costs must be internalized in order to realize the advantages of sustainable products. Informational deficits and asymmetries need to be overcome, for instance with the inclusion of knowledge about innovative products and processes in education.

For the case of increasing the share of timber as a sustainable building material in the German buildings construction sector this means, first of all, that state actors need to adapt a legal framework in order to overcome path dependencies which exist in favor of conventional construction materials. The promotion of competing uses of wood by the law on renewable energies may lead to market distortions. The EU ETS is of particular importance in respect of the internalization of environmental costs of manufacturing concrete, steel, and aluminum. Circular economy law provides important framework conditions for the recycling/disposal of all types of construction products.

4.3.1. Legal Framework for Conventional Building Materials

In order to initiate a path change in favor of sustainable building materials, the currently most utilized building materials in terms of volume—steel, aluminum, and concrete—must be deliberately included in the structural change. The most important leverage point in this respect is the internalization of environmental costs (cf. for the environmental effects of the production of conventional construction materials Section 2.1). In general, the pricing of environmental goods is one of the key areas for incentivizing resource protection [68,69]. The extraction and consumption of gravel, sand, limestone, and clay are currently not subject to special levies in Germany. Many European and non-European states—for example, the UK, Denmark, and Minnesota (USA)—apply a tax on primary building materials. This form of levy redefines scarcity prices for finite resources. Beyond that, it organizes resource conservation in an efficient manner and contributes to resource efficiency [70]. In general, in a European comparison, Germany's taxation of resources and environmental consumption rather lags behind [71], so that considerable potential can be identified here. Primary taxes on building materials could help to promote a shift from mineral building materials to renewable building products, especially timber [14]. Other possible steering effects are the extension of the useful life of buildings and an increase in the use of recycled building materials.

4.3.2. Law on Renewable Energies

Wood-based energy applications have been supported in Germany under the Renewable Energy Sources Act (EEG) in the electricity sector and incentives in the heating sector since the year 2000. The promotion of renewable energies has led to competition between the material and energy use of wood. A high willingness to pay for direct energy use of wood reduces incentives for cascading use. It can be assumed that this is also economically inappropriate (cf. Section 2.3). However, the pace of expansion has slowed down in recent years. In any case, in the area of power generation, the extraction of wood should not be increased again [24].

4.3.3. EU Emissions Trading Scheme

With regard to the internalization of environmental costs of the production of cement, steel, and aluminum, the EU ETS has only a limited impact on production costs. Also in the 4th trading period beginning 2021 there are plans to allocate free emission allowances to the cement and steel industries. A functioning EU ETS could help to enhance the climate-protecting effect of building with wood [21,24].

4.3.4. Circular Economy Law

Circular economy law establishes rules for the recycling or disposal of building products at the end of their life cycle. It also sets conditions for the use of construction and demolition waste as secondary raw material in the buildings construction sector. Compared to concrete and other mineral building materials, wood has advantages in terms of recyclability, as well as energetic recovery at the end of the life cycle, although composites and engineered timber may restrain this. The draft

regulation on substitute building materials in Germany (*Entwurf einer Ersatzbaustoffverordnung*, Federal Council Journal no. 566/17) aims to ensure the best possible recovery of mineral waste and to adapt the requirements for the sustainable securing and restoration of soil functions during backfilling to the current state of knowledge. The tightening of the requirements of circular economy law by this regulation and other future legal acts represents a step in the right direction, because this can bring out the advantages of timber as a construction material in respect to the closing of material cycles. However, timber is not per se better than conventional building materials in this regard, in particular if it is used in composites or modified. Therefore, the deconstruction, re-use, and recycling of the products already need to be considered in the process of planning a timber construction. To ensure sustainability, a long-term and material-efficient use of premium quality wood (such as laminated wood, plywood, timber frame construction) is necessary [35].

4.4. Third Transformation Phase: Setting New Ground Rules

In phase 3, transformation comes to an end, once the alternative system configuration is established as a new equilibrium and accepted as normality. Like in the "old" system, incremental innovations take place that improve the new system [5]. The governance task in this phase is to secure course stability. The legal framework designed in the second phase needs to be continually streamlined to the requirements of the new system (new infrastructures and technologies, new products, actors, and markets etc.). The new equilibrium must be supported by a legal framework underpinning the confidence of the market actors in the future framework conditions. For the case study, this means that the achievements of phase 2 need to be maintained, i.e. enabling rules for timber construction and restricting rules for cement, steel, and aluminum. After innovative products have penetrated the market and an information spill-over to architects, building planners, and building supervisory authorities has taken place, the market support programs established in the first transformation phase may be phased-out. The governance tasks in the third transformation phase are not explicitly covered by any approach of the TEP concept.

4.5. Accompanying Tasks in All Three Transformation Phases

Approaches (7) and (8)—involvement of new actors and time strategies—have not yet been included in the analysis. They refer to overarching aspects which need to be taken into account in all three transformation phases.

5. Conclusions

The legal framework currently in force is tailored to conventional building products and technologies. Therefore, law in general may pose an obstacle to transformation. Law is quite static because legislative processes for the amendment of existing law take time. On the other hand, law has huge potential to trigger and steer a transformation to sustainability, in combination with economics, planning, and other instruments, as well as other political measures. The analysis showed that in the governance of transformations/transitions to sustainability, law is necessary for interventions in all three transformation phases. In the first phase it is essential that law offers flexibility for innovations. In the second phase political actors need to systematically restrict old structures in order not to jeopardize the successes of the first phase. Here, strict rules and also economic instruments should be applied. In the third phase governments need to sustain the legal conditions created in the second phase. Another result of the analysis is that the concept of transformative environmental policy helps to shape policy interventions in order to transform systems towards more sustainability. Approach 5 and 6 of the TEP concept need law to be implemented explicitly.

Regarding the increase of the share of timber as sustainable building material in the German buildings construction sector, the survey showed that in the first phase existing policies and regulations for buildings construction, especially building law and building products law need to be adapted to the new building methods of "greener" construction. Because of market distortions in favor of

conventional building products, instruments for the promotion of sustainable building materials are also pivotal. In the second phase state actors need to adapt the legal framework in order to overcome path dependencies existing in favor of conventional construction materials. Primary taxes on building materials could help to promote a shift from mineral building materials to timber. A functioning EU ETS could help timber to deliver its advantages in terms of climate protection. Another benefit of timber is that it may be applied in cascading use. However, timber does not per se contribute to the closing of material cycles, in particular if it is used in composites or modified. Therefore, the deconstruction, re-use, and recycling of the products already need to be considered in the process of planning a timber construction. To ensure sustainability, a long-term and material-efficient use of premium quality wood (such as laminated wood, plywood, timber frame construction) is necessary. In order to initially produce sufficient wood for material applications in the wood cascade, the promotion of the use of primary wood as an energy source must be kept to a reasonable level. Measures to ensure sustainability in value chains must be implemented at an early stage, so that any pulling effect that may arise on the market does not lead to the creation of any new sustainability problems.

In the third transformation phase, the new system needs to be stabilized. The achievements of phase 2 need to be maintained, i.e. enabling rules for timber construction and restricting rules for cement, steel, and aluminum. Should the demand for timber exceed the level that can be made available on the market sustainably, the legal framework should be adapted in the sense of a "learning governance" [24]. In sum, the study showed that thinking in systems can help lawyers to understand which adaptations of the legal framework are necessary over time in a transformation to sustainability. The case study demonstrated that solving environmental problems linked to the use of conventional building products in buildings construction requires thinking outside the box of environmental law. Furthermore, besides making amendments to the legal framework, the application of economics, planning, as well as political and informational instruments is needed.

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