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Bioenergy governance between market and government failures: A new institutional economics perspective

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Abstract

Bioenergy can play an important part in managing the transition towards a low-carbon energy system. However, in many countries its rapid expansion increases pressures on agricultural land use and natural ecosystems, resulting in conflicts with conservation aims and food security. Establishing an effective governance framework for bioenergy, to safeguard against sustainability risks and promote the efficient use of scarce biomass resources, is of the utmost importance, but is complicated by the existence of multiple objectives, multiple market failures and the variety of possible value chains. In this situation, policy recommendations based on neoclassical assumptions prove too abstract to be of practical relevance. Using the case of European bioenergy policy, this paper explores how economic bioenergy policy recommendations could be improved by using a new institutional economics (NIE) perspective. Moving along the value chain, we discuss what implications the consideration of transaction costs, incomplete information, path dependencies, and political feasibility has for finding solutions to the governance challenges of bioenergy. We conclude that policy implications derived from NIE differ clearly both from neoclassical recommendations and current EU bioenergy policy, and that a NIE framework for the analysis of bioenergy governance, which takes not only market failures, but also the risks of government failures into account, could make a useful contribution to the development of realistic, “second-best” solutions to the allocative problems of bioenergy use.

Keywords: Bioenergy policy, renewable energy policy, climate change mitigation, new institutional economics

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1. Introduction

Bioenergy is seen as an important option for the reduction of carbon emissions in the energy sector and increasing the security of energy supply, while simultaneously offering chances for rural income generation and development (COM, 2005; GBEP, 2008). Consequently, many governments have adopted ambitious expansion plans, among them the European Union, the United States, Brazil, and China (GBEP, 2008; REN21, 2011). For the EU, bioenergy plays an important part in realizing renewable energy targets for 2020, as laid down in the Renewable Energy Directive (RED) (COM, 2009). In order to achieve a 20% share of renewable energy sources (RES) in Community energy consumption and a 10% share in transport, EU-27 member states expect energy production from biomass to more than double compared to 2005 levels, from 61 Mtoe in 2005 to 140 Mtoe in 2020 (Beurskens et al., 2011).

However, the rapid expansion of bioenergy use entails sustainability risks and increases competition between various alternative uses for land and biomass resources. Firstly, additional demand for biomass increases pressures on agricultural land use, thereby incentivising the conversion of natural land and increases in agricultural intensification (Berndes et al., 2010; Edwards et al., 2010). Apart from conflicts with conservation aims, emissions associated with land use change (LUC) can significantly deteriorate the greenhouse gas (GHG) balance of bioenergy (Fargione et al., 2008; Lange, 2011; Stehfest et al., 2010; Sterner and Fritsche, 2011). Secondly, displacing food and feedstock production with energy crop cultivation results in rising price levels for agricultural commodities, which may in turn negatively impact food security and cause indirect land use changes (ILUC) (CE Delft et al., 2010; FAO, 2008; Nuffield Council on Bioethics, 2011; Searchinger, 2009; WBGU, 2008). Moreover, energy-related biomass uses compete for biogenic resources not only with various material applications, but also among each other (Ericson, 2009), while competition for public support, research funds and investment capital exists with other climate change mitigation options. It is therefore necessary to establish a governance framework that succeeds not only in safeguarding the sustainability of bioenergy production, but also the efficiency of resource use (WBGU, 2008).

The resulting regulative problem is complicated by the existence of multiple relevant market failures, conflicts between policy objectives, the heterogeneity of bioenergy pathways, and the transregionality of value chains. In this situation, applying the tools of economic analysis can make a useful contribution toward structuring the problems of bioenergy governance and developing recommendations for choosing between regulation and markets as governance mechanisms. However, basing economic policy analysis on abstract assumptions from neoclassical theory, such as perfect information, the absence of transaction costs, perfectly competitive markets, or disinterested, welfare maximising policy makers, fails to account for factors which are highly relevant in the bioenergy context. Theoretical first-best solutions resting on these assumptions neglect not only practical and political feasibility constraints, but also fall short of addressing the complexity of the governance problem (cf. Demsetz, 1969; Dietz and Vanderstraaten, 1992). This paper therefore aims to explore how the practical relevance of economic bioenergy policy recommendations could be improved by employing a new institutional economics (NIE) approach, which takes the role of transaction costs, incomplete information, path dependencies, and political feasibility considerations into account. As an example we choose European bioenergy policy, because the EU is one of the main supporters of modern bioenergy pathways globally (REN21, 2011). First, we give a short overview of current European bioenergy policy, followed by a critical discussion of recommendations derived from neoclassical economic theory. Then, how a NIE perspective differs from neoclassical findings when assessing governance options for the different allocative problems occurring along a bioenergy value chain is explored. Based on this, we outline a NIE framework for analysing bioenergy governance options, and discuss general implications for bioenergy policy design.

2. European bioenergy policy: The gap between reality and neoclassical policy advice

2.1 European bioenergy policy: Approach and shortcomings

Policy measures relevant for bioenergy originate both from the European and member state level, and are directed either at the production of biomass and bioenergy carriers or their utilisation in the electricity, heating and transport sectors (see tab. 1). In the production sphere, energy feedstocks produced on agricultural land within the EU are subject to the same environmental and agricultural framework conditions as other agricultural production. Production-side support for energy crop cultivation was abolished in 2008 as part of the Common Agricultural Policy's (CAP) Health Check Reform, but certain types of bioenergy operations can still receive financing from the CAP's rural development budget (DG AGRI, 2012). In addition, domestic biomass producers benefit from import tariffs on liquid biofuels and certain intermediate products (Junginger et al., 2011).

In the utilisation sphere, the principle European instrument for the promotion of bioenergy is the Renewable Energy Directive (RED), with its binding renewable energy targets (see tab. 1) (COM, 2009). The choice of support instruments and technology mixes employed in meeting national targets remains up to member states; National Renewable Energy Action Plans show bioenergy as the central option for expanding renewable energy use in the transport and heating sectors, and an important contributor in the electricity sector (Beurskens et al., 2011). Only for biofuels (i.e. liquid and gaseous bioenergy carriers for transport) and other bioliquids does the RED require member states to implement sustainability criteria (COM, 2009).[1] In order for biofuels to count towards the targets, producers have to prove via certification that raw materials do not originate from areas with high biodiversity value or carbon stocks, that agricultural cultivation within the EU adheres to environmental minimum requirements, and that biofuels have a GHG mitigation potential of at least 35% (increasing to 50% from 2017, and 60% from 2018). While this includes emissions from direct land use changes, ILUC effects have been considered only through regular reporting to the legislator (COM, 2009). For solid biomass and gaseous bioenergy carriers in the electricity and heating sectors, the implementation of sustainability schemes remains voluntary so far (COM, 2010a).

Apart from RES targets, the European Emission Trading System (ETS) affects the demand for bioenergy by increasing the price of fossil fuel substitutes in the electricity sector and aviation. Although the ETS is seen as a “central pillar of European climate policy” (COM, 2011, p. 16), carbon certificate prices are currently too low to offer investment incentives for bioenergy (Tuerk et al., 2011).

On the national level, member states primarily employ sector-specific, utilisation-side measures for supporting bioenergy (IEA and IRENA, 2012). Specific policy measures and both the level and sectoral focus of bioenergy use vary, depending on available biomass resources, national energy system structures and political priorities (DG Energy, 2009; Faaij, 2006). Table 1 illustrates the bioenergy policy mix for the example of Germany, the member state with the highest amount of bioenergy use (Eurostat, 2011). In addition to direct support instruments, measures affecting substitutes such as taxes on fossil fuels and the nuclear phase-out are also relevant.

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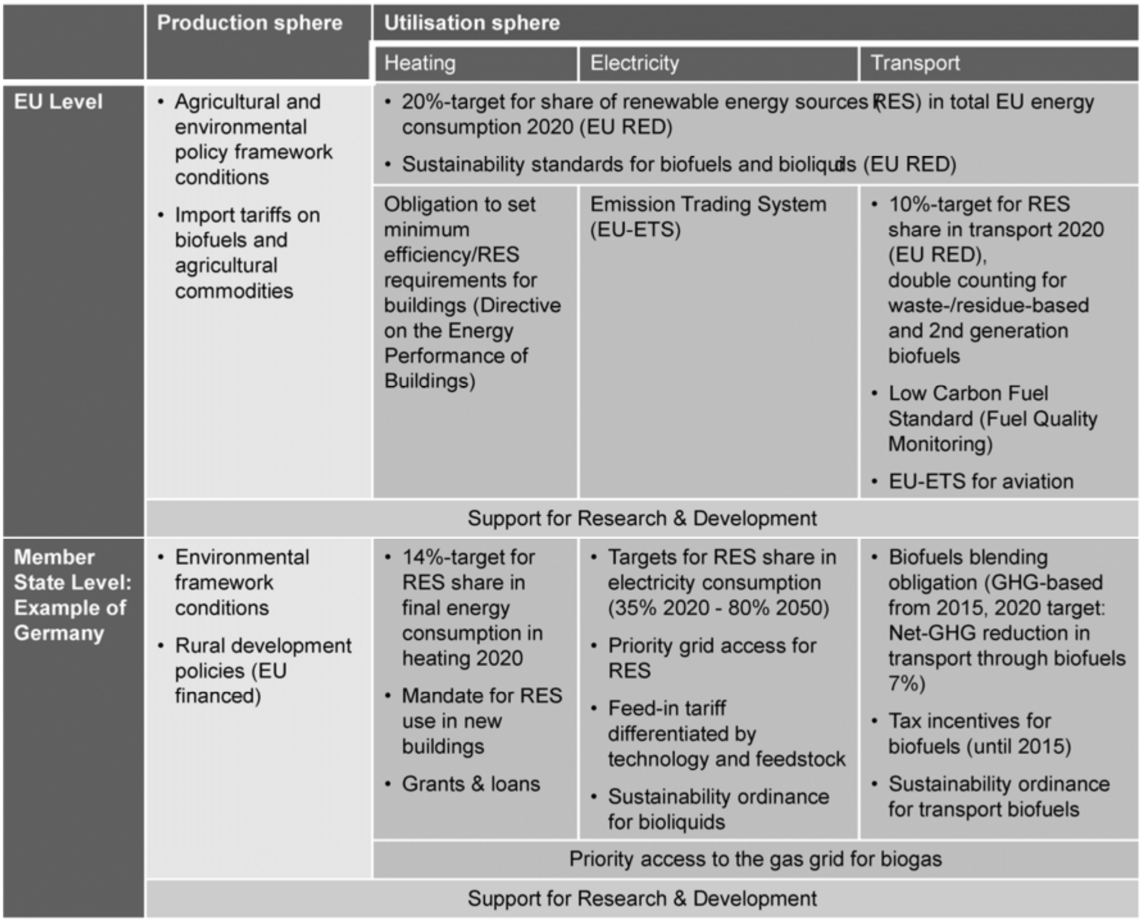
[1] This focus of EU sustainability regulation results from: a) the close link between biofuel production and first generation energy crops, which have been heavily criticised for adverse land use change impacts and poor GHG balances (e. g. Searchinger 2009; Fargione et al. 2008); b) the fact that biofuels constitute the main option for meeting the RES target in the transport sector (cf. Beurskens et al., 2011), and c) the relevance of biofuel imports from Non-EU countries (cf. Beurskens et al., 2011).



	Production sphere	Utilisation sphere		
		Heating	Electricity	Transport
EU Level	• Agricultural and environmental policy framework conditions • Import tariffs on biofuels and agricultural commodities	• 20%-target for share of renewable energy sources (RES) in total EU energy consumption 2020 (EU RED) • Sustainability standards for biofuels and bioliquids (EU RED)		
		Obligation to set minimum efficiency/RES requirements for buildings (Directive on the Energy Performance of Buildings)	Emission Trading System (EU-ETS)	• 10%-target for RES share in transport 2020 (EU RED), double counting for waste-/residue-based and 2nd generation biofuels • Low Carbon Fuel Standard (Fuel Quality Monitoring) • EU-ETS for aviation
	Support for Research & Development			
Member State Level: Example of Germany	• Environmental framework conditions • Rural development policies (EU financed)	• 14%-target for RES share in final energy consumption in heating 2020 • Mandate for RES use in new buildings • Grants & loans	• Targets for RES share in electricity consumption (35% 2020 - 80% 2050) • Priority grid access for RES • Feed-in tariff differentiated by technology and feedstock • Sustainability ordinance for bioliquids	• Biofuels blending obligation (GHG-based from 2015, 2020 target: Net-GHG reduction in transport through biofuels 7%) • Tax incentives for biofuels (until 2015) • Sustainability ordinance for transport biofuels
		Priority access to the gas grid for biogas		
	Support for Research & Development			

Tab. 1 Instruments of European and German bioenergy policy (own compilation, based on BMU, 2012; DG Energy, 2012; DG Environment, 2012; Federal Republic of Germany, 2010)

In assessing European bioenergy policy, the main strands of critique relate to the insufficiency of sustainability regulation and a lack of efficiency in support design (see SRU, 2007; WBGU, 2008 for a summary). While sustainability standards are so far only mandatory for biofuels and bioliquids, trade in solid biomass is also increasing, while importing biomethane via gas pipelines may gain relevance in the future (Heinimö and Junginger, 2009; Nollmann, 2012). An early harmonisation of sustainability criteria for all bioenergy carriers therefore seems desirable. Also, broader environmental issues of biomass production, like impacts on water, soil and agricultural biodiversity, or social effects, remain outside the coverage of mandatory certification schemes (Fritsche et al., 2010; van Dam et al., 2010). Moreover, dealing with the impacts of bioenergy demand on global food security and ILUC constitutes a major problem. Resulting from macroeconomic price effects on agricultural commodity markets, these issues are beyond the scope of certification, and remain the subject of lively debates among EU policy makers, stakeholders and research communities (Di Lucia et al., 2012; Fritsche et al., 2012; Gawel and Ludwig, 2011; COM, 2010b). From an efficiency viewpoint, a lack of coordination between sectoral support measures (Kopmann et al., 2009; SRU, 2007; WBGU, 2008), particularly the failure of unifying carbon abatement costs (Kopmann et al., 2009; WBA, 2007) are criticised. In all three energy sectors, the expansion of biomass use is supported through a variety of measures; a mainly quantitative approach, however, neglects the existence of multiple competing uses for scarce biomass and land resources. An optimisation of biomass use is further impeded by the fact that different support instruments reflect different political priorities (Henke and Klepper, 2006; Isermeyer and Zimmer, 2006). Import tariffs on biofuels, for example, favour the objective of domestic value creation, but increase the costs of bioenergy expansion. In the case of biofuel quotas, which set strong signals for bioenergy pathways with comparatively high GHG mitigation costs (cf. Sterner and Fritsche, 2011), the focus seems to be on security of supply considerations (Berndes and Hansson, 2007).

2.2 Principles and limits of a neoclassical bioenergy strategy

Policy recommendations derived from neoclassical economic theory differ strongly from the instrument mixes employed by the EU and its member states. In a neoclassical bioenergy strategy, the rationale for policy interventions would be the objective of climate change mitigation – markets fail in providing sufficient levels of renewable energy supply, because the climate externalities of energy production are not fully reflected in energy prices. Regarding ‘security of supply’ considerations and rural development aims, the case for bioenergy support is less clear. Support for certain agricultural sectors may perpetuate structural problems and delay market adjustment processes, while uncertainties about sustainable long-term potentials for energetic biomass uses and the high costs of biofuels make it questionable whether bioenergy is a suitable means to substantially improve the security of energy supply (Berndes and Hansson, 2007; Isermeyer and Zimmer, 2006).

The recommended solution for an efficient climate policy consists of an internalisation of the costs of carbon dioxide emissions. For meeting a given emission reduction target at the least costs to an economy, establishing a sector-spanning emission trading system constitutes a theoretical first-best solution (e.g. Endres and Fraser, 2010). Since emitters with different abatement opportunities can trade emission allowances, the marginal costs of climate change mitigation would converge across all participating sectors. Here, different bioenergy pathways would compete with alternative abatement options, like other RES or energy efficiency measures, according to their GHG mitigation costs (Kopmann et al., 2009). In a first-best world, employing further instruments to support specific technologies – as is the rule in EU RES policy – would only distort market search processes for least-cost abatement options and result in efficiency losses (see e.g. Frondel et al., 2010).

However, this recommendation is based on a number of problematic assumptions (Lehmann and Gawel, 2011). Namely, it is assumed that (i) technology and innovation markets function efficiently; (ii) institutional framework conditions beyond energy technology markets do not play a role; (iii) policy interventions are designed welfare-optimally; (iv) climate change mitigation is the only relevant policy aim, and that (v) a differentiation of bioenergy pathways by carbon mitigation costs is sufficient. Compared with reality, these assumptions prove to be highly abstract, substantially limiting the practical relevance of policy advice based upon them.

First, even if climate change externalities were perfectly internalised, further market failures in the energy technology markets prevent optimal technology choices. As companies are unable to capture the full benefits of investments in innovation and learning, both R&D and the deployment of innovative energy technologies are lower than socially desirable in a market context (Jaffe et al., 2005; Lehmann and Gawel, 2011; Newell, 2010). Also, market power on the side of incumbents can create entry barriers for innovators, because past investments in fossil fuel plants constitute sunk costs which can be ignored in price setting (Fritsch, 2011).

Second, infrastructural, technological and institutional path dependencies interact to create a "carbon lock-in" of the energy system, imposing considerable difficulties on realising a system transformation towards low-carbon technologies (Unruh, 2000).

Third, political framework conditions do not provide a level playing field for RES, and real-world measures like the EU-ETS differ considerably from theoretical recommendations (see e.g. Anthoff and Hahn, 2010; Lehmann et al., 2012). One reason for these differences is that an "ideal" system would be associated with high transaction costs (Krutilla and Krause, 2011). In order to achieve an optimal allocation of energetic biomass uses, an emission trading system would have to not only encompass the electricity, heating and transport sectors, but also account for land use emissions, necessitating the inclusion of further greenhouse gases like methane and nitrous oxide. The compilation of reliable information about the GHG balances of complex and heterogeneous bioenergy pathways alone poses considerable challenges (cf. Creutzig et al., 2012). To address international leakage and rebound effects, a first-best emissions trading system would also require global coverage and compliance. Besides transaction cost considerations, the political feasibility of such a system is questionable. Rather than aiming at total welfare maximisation, the political process follows its own dynamics, and impacts of policy measures on voter and interest group support are an important variable for self-interested political decision makers (Anthoff and Hahn, 2010; Helm, 2010). Closely related is the importance of policy objectives other than climate change mitigation which need to be taken into account when formulating policy advice (cf. Lehmann and Gawel, 2011; Matthes, 2010). Security of supply considerations and industrial policy, for instance, provide further rationales for supporting RES expansion; if achieving high shares of RES in the energy system constitutes an aim in itself (cf. COM, 2009; Federal Republic of Germany, 2010), the GHG mitigation costs of different RES options are no longer the only criterion to guide technology choices, as what RES technologies are available for deployment in a given sector becomes an important determinant.

Lastly, in the case of bioenergy, the governance problem is more complex than even a perfect emission trading system including land use emissions could account for. Beside climate externalities (both positive and negative), bioenergy pathways are associated with various other environmental and social impacts occurring on different spatial scales, which necessitate interventions on different governance levels.

Taken together, these considerations considerably limit not only the likelihood of implementation, but also the adequacy of the first-best neoclassical recommendation. Rather, a policy mix is required to address the multiple challenges involved in climate and bioenergy policy (Bennear and Stavins, 2007; Lehmann and Gawel, 2011; Matthes, 2010; Neuhoff, 2005). Regarding the composition of such a policy mix, economic analysis can make an important contribution towards addressing the deficits of current EU policy. However, besides the efficiency of policies, the practical and political feasibility of measures in an imperfect world needs to be taken into account. By considering transaction costs, incomplete and asymmetric information, path dependencies, and the implications of self-interested policy makers, new institutional economic theory can provide a framework which allows for a structured analysis of governance options, while remaining closer to reality than the neoclassical approach with its abstract assumptions. As a first step towards such an analysis, we examine in the following what difference a NIE perspective makes for policy recommendations compared to the neoclassical approach.

3. Challenges of bioenergy governance

GHG mitigation potentials, cost characteristics and wider environmental and socio-economic impacts of bioenergy pathways are influenced by a variety of allocation decisions taken along heterogeneous and transregional value chains (see fig. 1). At the production, conversion and utilisation stages, actors’ decisions are not only influenced by political and economic framework conditions, but also by technological constraints – specific sectoral applications demand specific bioenergy technologies, which again determine what types of biomass can be used. As a result, the problem of optimising bioenergy production and use is characterized by a high degree of complexity. For each step of the value chain, several distinct allocative problems can be identified. A basic question brought up by an analysis of bioenergy governance options is therefore where along the value chain markets fail, necessitating policy intervention. Conversely, it has to be considered where these interventions are likely to be successful, and where the risks of government failure may be high.

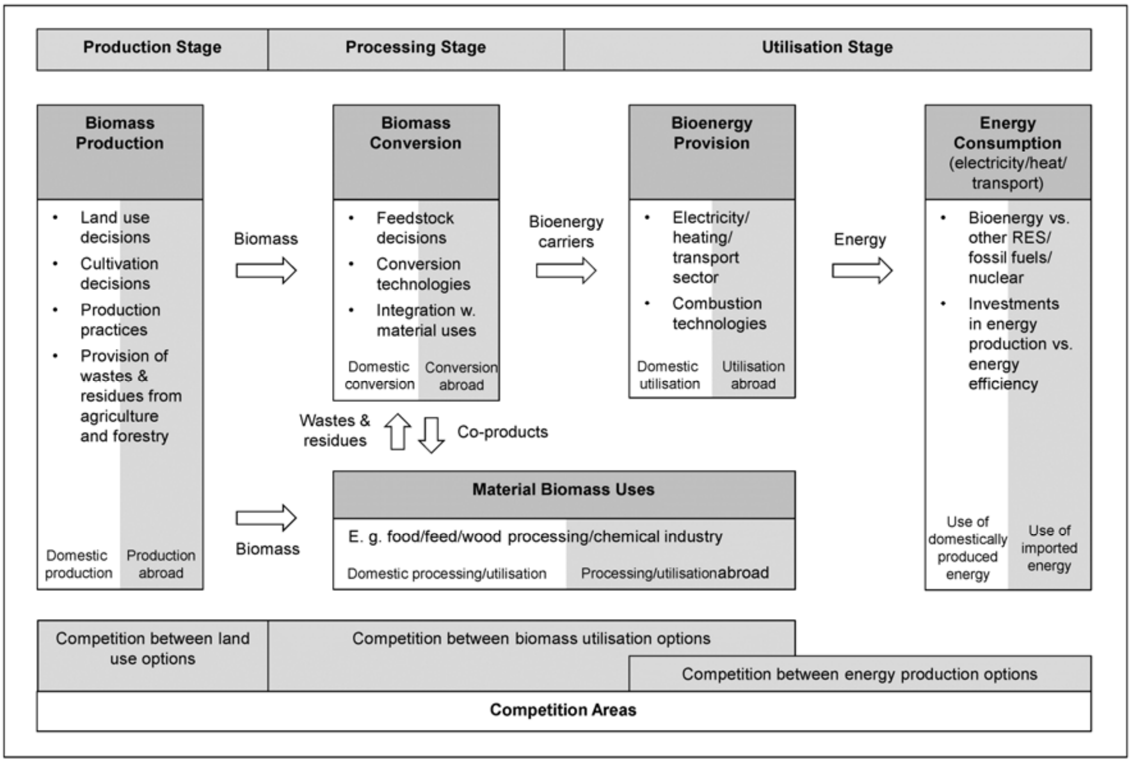


Fig. 1 Allocation decisions and areas of competition along a bioenergy value chain (own representation)

From a standard economics perspective, prices provide the information and incentives needed to organize decisions about the allocation of marketable goods, bringing about an optimal allocative outcome if markets function perfectly. Accordingly, in standard welfare economics, government interventions are called for if market failures such as technological externalities, market power, lack of information and deficiencies in market adjustment processes arise, and should – in a first-best world – strive to establish a welfare optimum (Fritsch, 2011). Government failure, in this sense, comes about if state intervention does not succeed in addressing market failures effectively and efficiently, or if an intervention into a functioning market impairs the market allocation mechanism (Fritsch, 2011; Winston, 2006). However, as Coase (2010) showed, both market mechanisms and regulation involve transaction costs, which need to be taken into account when evaluating alternative governance options. In some cases, the transaction costs of introducing regulation may even be so high as to make it preferable to leave market failures unattended. To derive recommendations for a real world policy situation, where both markets and government interventions are likely to fail in bringing about an optimal allocative outcome, it is therefore necessary to compare the respective costs and benefits of alternative institutional arrangements (Demsetz, 1969; Dixit, 1996; North, 1990; Williamson, 1996).

In the following, we give an overview of the allocative problems of bioenergy use, and highlight where markets fail in addressing them. Based on this, the differences between policy implications derived from neoclassical theory and a new institutional economics perspective are discussed, taking not only market failures, but also the risks of government failures into account.

3.1 Production sphere

In the production sphere, the following allocative problems arise:

(i) How to solve competition between alternative land uses, and how to avoid undesirable land use changes? Among the various resources available for bioenergy production, energy crops are estimated to have the largest potential for meeting the globally increasing bioenergy demand (Chum et al., 2011). However, given the limited availability of arable land, the growing of energy feedstocks competes for suitable areas with the production of other commodities, but also with land use options like extensive grazing or the conservation of natural ecosystems (CE Delft et al., 2010). Depending on demand, biomass producers change production patterns and expand the area under cultivation, by restoring degraded land, developing marginal land or converting natural areas. In response to land use and cultivation decisions, scarcity relations and prices on commodity markets change, causing further market adaptation processes.

(ii) How to coordinate decisions about crops and production practices? Besides the nature of former land uses, the choice of crops and production practices has a significant influence on the environmental and socio-economic balance of bioenergy. Here, yield expectations combined with production systems’ requirements for fertilizer, pesticides and irrigation are of relevance, as well as decisions about whether to make residues and wastes available for further uses, (Rossi, 2012). Agri-environment measures may provide environmental benefits (Rossi, 2012), while decisions on labour conditions and wages, for instance, affect the socio-economic balance of production (Beall and Rossi, 2011). As different bioenergy technologies demand different types of biomass, decisions in the production sphere have important implications for the remainder of the value chain.

(iii) Where to locate production? Location decisions influence cost characteristics, but can also have impacts on the socio-economic and environmental balance of biomass production, given differences in local governance frameworks (see also 3.2) (IEA Bioenergy, 2009).

In a market solution for these allocative problems, actors attempt to maximise the difference between costs and attainable commodity price. However, in practice several market failures typically arise in this field. On the producer level, environmental and social costs are taken into account neither in the choice of crops and production practices, nor in land use decisions, because they are not fully reflected in market prices. This classic public good problem interacts with information asymmetries between producers and consumers (Schubert and Blasch, 2010). As bioenergy carriers bear no information as to their associated external costs, goods with a higher environmental and social quality get crowded out of the market (cf. Akerlof, 1970). Given a relatively limited willingness to pay for public good characteristics of products, a private internalisation of external effects, e.g. through voluntary certification schemes, seems restricted to niche applications (Schubert and Blasch, 2010). Moreover, production decisions do not take macro-economic consequences into account. So far, material uses of agricultural crops tend to be more profitable than energetic ones, and for the most part, only the provision of low cost resources (e.g. some wastes and residues) is viable in the absence of policy incentives (Ericson, 2009). However, if future fossil fuel price developments were to endow energetic uses with a higher ability to pay than food-related uses, the consequences for food security would be problematic. Likewise, ILUC effects are beyond the purview of individual producers.

From a neoclassical perspective, an optimal policy approach would internalise the external costs and benefits of biomass production, e.g. through integrating land use emissions in a global emission trading mechanism, and payment for ecosystem services schemes. Food security concerns, meanwhile, may be mitigated through increases in agricultural output and technical progress, which are both incentivised by higher price levels for agricultural commodities. This perspective, however, neglects the sustainable limits of global agricultural production systems, which place questions about the distribution of resources between competing demands back on the agenda (cf. Faber, 2008). Comprehensive internalisation approaches in the land use sector, meanwhile, are likely to incur considerable transaction costs, given the task of quantifying multiple externalities, the high number and fragmented nature of affected actors, and information asymmetries between producers and regulators. Moreover, the spatial scale of externalities needs to be taken into account when formulating policy recommendations (Thrän et al., 2010). Environmental and social effects of biomass production can range from the local (e.g. water scarcity) to the global level (e.g. GHG emissions from land use changes), necessitating a discussion about where regulative responsibilities lie, and which government levels are likely to address challenges most effectively.

Given the problems of a first-best internalisation approach, the global implementation of sustainable land use standards for all agricultural activities, either through national regulation or international agreements, would constitute a second-best option to address market failures in the production sphere (Scarlat and Dallemand, 2011; WBGU, 2008). Such standards are required to address direct and indirect land use changes effectively; indeed, within a consistent environmental policy framework, the concept of ILUC would become irrelevant. However, lack of political will and/or enforcement capacity in producer countries proves problematic. Thus, even though relevant externalities and information asymmetries apply to all agricultural production, a case for bioenergy-specific regulation can be made (WBGU, 2008). Influencing allocation decisions in the production sphere through demand-side regulation constitutes a policy option which may be “third-best” in its effectiveness and efficiency, but can be implemented unilaterally by the EU and is feasible in the short term.

However, in designing such a “third-best” option, policy makers are faced with central questions about where in the value chain to place their interventions, which issues to address through EU regulation, and which to leave up to producer countries. Combining minimum standards for bioenergy carriers with mandatory certification, for instance, sets sustainability incentives for the production sphere and addresses the problem of information asymmetries (Schubert and Blasch, 2010); on the other hand, a trade-off exists between the comprehensiveness of schemes, and transaction costs as well as political feasibility (Smeets and Faaij, 2010; Vis et al., 2008). A differentiation of utilisation-side support, e.g. through feedstock-specific feed-in tariffs, may generate stronger incentives for biomass production systems which are deemed particularly sustainable, but information requirements for policy makers are high. Moreover, the coordination of land use decisions abroad remains problematic, and a potential source of government failure. For example, the EU Renewable Energy Directive stresses the role of degraded land for sustainable bioenergy production as a means to reduce land use competition (COM, 2009), but as yet it seems unclear how to ensure that such land is in fact prioritized over more profitable arable land (cf. Lange, 2011). The handling of ILUC and other leakage effects, e.g. the rerouting of trade streams to regions without sustainability requirements (Di Lucia, 2010; van Dam et al., 2010; Van Stappen et al., 2011) remains another challenge.

3.2 Processing sphere

In the processing sphere, allocative problems are:

(i) How to solve (and reduce) competition between material and energetic biomass uses? On commodity markets, producers of bioenergy carriers compete for biomass resources with material applications, such as food and feed production, wood processing, and chemical industries (Ericson, 2009). In particular, competition between crops which can be used both for food and energy production is criticized for problematic impacts on global food price developments (FAO, 2008; Nuffield Council on Bioethics, 2011; WBGU, 2008). Also for other material uses, the importance of developing renewable resources is rising (COM, 2012).

(ii) How to coordinate decisions about conversion technologies? For the production of gaseous, solid or liquid bioenergy carriers, a variety of technologies can be employed, which differ in their stage of development, costs, conversion efficiencies, and range of suitable feedstocks (Chum et al., 2011; IEA Bioenergy, 2009; JRC-IET, 2011). Depending on the technology-feedstock combination adopted, producing co-products for material applications may be possible. Likewise, wastes and residues from material biomass uses can be converted to bioenergy carriers. For relaxing competition between material and energetic biomass uses, the development of integrated solutions, such as cascading uses and biorefinery concepts, is seen as an important option (COM, 2012).

(iii) How to coordinate sourcing decisions for raw materials? Processors decide whether to source raw materials regionally, domestically or import them. In all cases, different degrees of integration between value chain components are possible, with trade on commodity markets, supply contracts with producers, foreign direct investment and on-farm processing representing some of the options.

In a market context, biomass is directed towards the applications with the highest value creation, while technology and sourcing decisions are determined by costs. But once again, price signals do not reflect the external costs and benefits of different utilisation options, and innovative technologies are undersupplied due to knowledge spillovers. Likewise, cost-driven sourcing decisions take neither the environmental costs of transport, nor environmental and social framework conditions in production countries into account – indeed, in as far as they decrease production costs, low regulative standards may even be construed as a competitive advantage (European Parliament, 2012).

As outlined in section 2.2, the neoclassical solution for optimising the use of biomass would be an internalisation of GHG emission costs at the utilisation stage, where bioenergy can act as a substitute for other energy sources. In this way, energetic biomass uses are imbued with an ability to pay for raw materials that is consistent with their external benefits, and incentives are set for the production of bioenergy carriers with advantageous GHG balances. To compensate for the external benefits of knowledge creation, innovative conversion technologies could be eligible for R&D support. Lastly, with sustainability concerns addressed at the production stage (see. 3.1), sourcing decisions should be left to the market, to make use of the advantages of an international division of labour.

However, this approach neglects that even if a complete internalisation of the climate benefits of bioenergy use were possible, competition between different material and energetic uses would remain distorted. For one, potential climate benefits of material uses would also have to be internalised (e.g. substituting concrete with wood); also, institutional framework conditions of the various material and energetic sectors differ considerably. Moreover, distributive aspects, e.g. impacts on food security, and other policy aims, like the international competitiveness of material industries, may make a complete internalisation of external effects undesirable. But if an allocation via administered markets remains imperfect, a central, regulative governance of biomass flows is also unlikely to succeed in bringing about an optimal allocative outcome. The variety of different uses, limited predictability of future developments, and uncertainty about the aggregated welfare effects of interventions all impose high information costs on a regulative allocation of biomass resources (see e.g. Mueller et al. (2011) regarding the uncertainties involved in estimating the food price effects of biofuels). As a result, one intervention in the competition between biomass uses could entail many further corrective measures (cf. Eucken, 1990).

Following from this, the NIE perspective agrees with the neoclassical approach that compensation for external benefits and deployment support should be located at the utilisation stage. Although allocation decisions in the processing sphere have important ramifications for the environmental balance of bioenergy and scarcity relations on biomass markets, the overall energetic and GHG balance of a pathway, as well as GHG mitigation costs, are determined at the combustion stage (see 3.3). Sourcing decisions, meanwhile, have to be considered in a real world context (see 3.1), where neither a perfect production-side internalisation of externalities nor effective governance frameworks in producer countries can be assumed. Consequently, additional measures, such as the mandatory certification of bioenergy carriers, are necessary to cause biomass processors to consider production conditions in their sourcing decisions. Meanwhile, the neoclassical recommendation to make use of international comparative advantages in sourcing decisions still holds from a NIE perspective, given that international trade is expected to significantly lower the economic costs of expanding bioenergy use (Ericson, 2009).

3.3 Utilisation sphere

The utilisation stage encompasses the following allocative challenges:

(i) How to allocate biomass resources to different energetic utilisation options in the electricity, heating and transport sector? As biomass resources available for energetic uses are limited, different applications in the electricity, heating and transport sectors compete for bioenergy carriers; associated increases in production costs reduce the competitiveness of bioenergy relative to other energy sources. Substituted energy sources differ depending on whether biomass is used for the generation of electricity or heat, or as a transport fuel, significantly influencing the GHG balance of respective bioenergy pathways (e.g. Sterner and Fritsche, 2011). Also, depending on available alternatives for renewable energy production in the different sectors, the importance of bioenergy under security of supply aspects varies.

(ii) How to coordinate sourcing decisions for energy and processed bioenergy carriers? Like raw biomass, bioenergy carriers can either be imported or sourced domestically by plant operators. Also more generally, the decision between energy imports and domestic production arises, with implications for energy security depending on energy carriers and export regions (CE Delft et al., 2010).

(iii) How to coordinate investment decisions between bioenergy, other energy production options and efficiency measures? In a given energy sector, bioenergy technologies compete with alternative energy production options, such as other RES, fossil fuels, or nuclear power, for market shares, investments and R&D capital. The competitiveness of bioenergy is primarily influenced by the costs of energy carriers, characteristics of combustion technologies and the scale of operations (Chum et al., 2011; JRC-IET, 2011). Additionally, the implementation of energy efficiency measures to reduce total energy demand constitutes an alternative option.

In the absence of political support, most bioenergy pathways are unable to compete with conventional energy technologies, mainly due to biomass costs and lack of technological maturity (JRC-IET, 2011).In a market context however, choices between alternative energy sources and technologies – as well as between different sectoral utilisation options of bioenergy – are distorted by multiple market failures, such as environmental externalities of energy production, positive externalities of innovation, market power, and path dependencies (see 2.2).

As outlined in section 2.2, it follows from a NIE perspective that, beyond a necessarily incomplete internalisation of climate costs, additional deployment support for renewable energy technologies is needed to address other market failures and break the "carbon lock-in" (e.g. Lehmann et al., 2012). Consequently, the question of how policy support should be designed to enable efficient choices between bioenergy and other renewable energy technologies arises. Furthermore, given that market structures, relevant actors and institutional barriers differ for the three energy sectors, sector-specific regulation is likely to be required. This confronts bioenergy policy with the problem of how to coordinate policy measures in electricity, heating and transport markets (SRU, 2007; WBGU, 2008).

For the design of deployment support, NIE offers important implications, which are well documented in the literature. The high asset specificity and longevity of energy sector investments make the creation of planning security for investors an important success factor of RES regulation (Finon and Perez, 2007; Menanteau et al., 2003). In particular, the political credibility of a scheme is crucial; if opportunistic behaviour on the side of policy makers is expected, high risk premiums are necessary to induce investment (Helm et al., 2003). Against this background, guaranteeing technology-specific support (such as feed-in tariffs) over a long time horizon is regarded as a successful instrument for promoting RES deployment, but trade-offs with efficiency may result (Finon and Perez, 2007; Menanteau et al., 2003). In designing support, policy makers are faced with uncertainty about costs and learning curve potentials of alternative technologies and sectoral biomass uses (Lesser and Su, 2008; Menanteau et al., 2003). For bioenergy in particular, information problems can be severe, as externalities occurring all along the value chain should be taken into account when differentiating between pathways (Gawel, 2011). Under these conditions, rent-seeking activities can be highly profitable, and regulative choices may result in new sub-optimal path dependencies.

Furthermore, conflicting policy aims can significantly reduce the efficiency of regulative measures in the utilisation sphere; depending on the prioritised aim, the sectoral focus of bioenergy support would differ considerably (see tab. 2). In particular, if policy makers are regarded as interest instead of welfare maximisers, they may be inclined to prioritise aims which find the support of well-organised constituents, like rural value creation, over objectives with a more diffuse advocacy, as would be the case for cost-efficient GHG mitigation (cf. Anthoff and Hahn, 2010; Pappenheim, 2001).

Dominant policy perspective	Priority aim	Focus of support
Climate policy	Climate change mitigation	Pathways with the highest GHG mitigation potentials and lowest GHG mitigation costs (favours e.g. combined heat and power applications)
Energy policy	Security of energy supply	Substitution of energy carriers with a high import dependency (primarily mineral oil and natural gas)
Agricultural policy	Rural development and rural value creation	Domestic production of energy crops
Industrial policy	Sectoral development, economic growth	Innovative value chains and exportable products
Environmental policy	Environmental quality	Pathways that do not cause a deterioration of environmental quality, or provide environmental benefits

Tab. 2 Focus of bioenergy support according to different political priorities (based on Berndes and Hansson, 2007; CE Delft et al., 2010; Isermeyer and Zimmer, 2006; WBGU, 2008)

4. Implications for bioenergy policy design

4.1 The contribution of a NIE perspective

As outlined above, market failures occur all along the bioenergy value chain. Neoclassical recommendations aim at modifying the market framework conditions in a way that would establish an optimal allocative solution, by perfectly correcting for market failures; typically, following the Tinbergen rule, one instrument would be recommended per market failure (Tinbergen, 1952). A NIE perspective, on the other hand, shows a more differentiated picture, as feasibility constraints of first-best solutions and the risks of government failure are taken into account. Overall, the central question of a NIE bioenergy governance analysis can be posed as follows: Given the existence of incomplete information, transaction costs, opportunistic behaviour, leakage, multi-level governance problems and institutional path dependencies, what governance arrangements are comparatively more successful in providing incentives for sustainability, cost-efficiency and innovation (see fig. 2)?

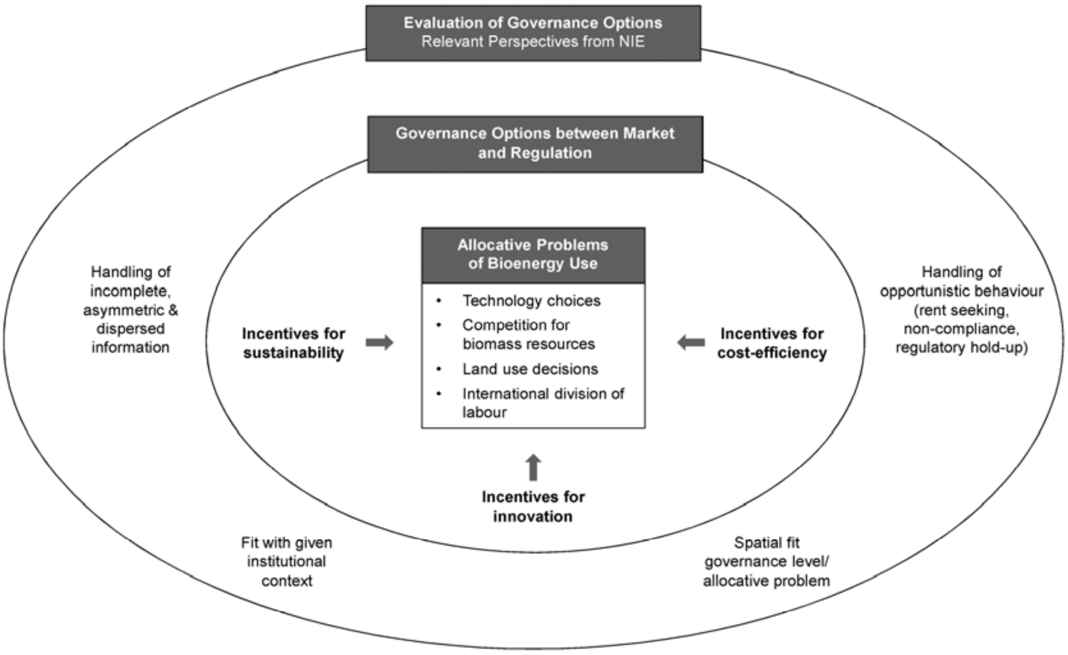


Fig. 2 NIE analysis of bioenergy governance: Research framework (based on Hayek, 1945; North, 1990; Williamson, 1996)

Throughout the bioenergy value chain, incomplete information and uncertainty are pervasive in allocation decisions. Here, several aspects are relevant for a NIE governance analysis. Firstly, it needs to be assessed how institutions set up as part of private or public governance structures reduce uncertainty and deal with information asymmetries between actors (North, 1990). Secondly, it is important how well alternative governance modes can coordinate and make use of knowledge which is dispersed across society (Hayek, 1945). Solutions to these information problems determine the transaction costs of alternative arrangements, which – encompassing search and information costs, bargaining and decision making costs, monitoring and enforcement costs – can be generalised as “resource losses incurred due to imperfect information” (Dahlman, 1979, p. 148).

Further governance problems arise if actors have incentives to behave opportunistically (Williamson, 1996). Especially when information is asymmetric and policy makers depend on market actors’ cooperation, rent seeking activities to influence regulation can be highly profitable (Verbruggen, 1991), whereas high monitoring and enforcement costs increase the risk of non-compliance with regulative measures (Krutilla and Krause, 2011). Safeguards against the risk of opportunistic behaviour on the side of policy makers are also necessary; if lacking credibility and constancy, incentives set by regulation would be greatly diminished in their effectiveness, especially if asset specificity and longevity of investments is as high as in the energy sector (Helm et al., 2003). Furthermore, taking the spatial scale of market failures into consideration, it has to be assessed at which governance level (e.g. local, national, EU or international) interventions should best be undertaken. Several governance levels may need to be involved to effectively address allocative challenges, and minimise leakage effects between different regulative jurisdictions; here, considering the transaction costs of coordinated policy responses seems very relevant. Additionally, institutional path dependencies limit the number of governance options that can be considered politically feasible; if actors have made specific investments based on the belief that a particular institutional framework will endure, or if institutions are complementary to each other, introducing changes which are incompatible with a given pathway can be associated with high transaction costs (North, 1990; Pappenheim, 2001).

Whereas a detailed analysis of bioenergy governance options is beyond the scope of this article, some general implications can be drawn from the NIE perspective on the challenges of bioenergy governance developed in chapter 3. The following section attempts an outline of where it may be advantageous to leave allocation decisions to the market, and where regulation is necessary and likely to lead to improved outcomes.

4.2 What follows for bioenergy policy?

By making use of decentralised trial-and-error processes, markets have a significant advantage in dealing with dispersed information and uncertainty (Hayek, 1945). If policy makers attempt to intervene in all allocation decisions where market failures are relevant, and establish a comprehensive governance of biomass flows, information requirements are unfeasibly high, and errors costly. It is therefore crucial to clearly determine where in the value chain interventions would be most effective. Since contributions to GHG mitigation and energy security are determined at the utilisation stage, it is recommendable to place the focus of interventions here (see SRU, 2007; WBGU, 2008). For a successful utilisation-side intervention, three policy components seem necessary (see 3.3). First, the playing field for RES and conventional energies should be levelled as much as politically feasible, e.g. by improving the EU-ETS, and increasing carbon taxes in non-ETS sectors. Second, additional instruments, such as deployment support for RES and bioenergy, are required; given multiple competing demands for land and biomass resources, the coordination of measures across sectors if of central importance for the efficiency of bioenergy policy. Lastly, utilisation-side interventions need to differentiate between bioenergy pathways according to their overall impacts, to set clear incentives for downstream allocation decisions.

The necessity for a cross-sectoral coordination of support and pathway differentiation constitutes a governance challenge which is particular to bioenergy. A detailed planning of what share of biomass should be used for electricity, heating or transport fuel production is complicated by uncertainties about future technology and cost developments, both concerning bioenergy and alternative RES options, and also by the ongoing emergence of new utilisation options for biomass (e.g. in air traffic (EBTP, 2012)). To guide the coordination between policy instruments and create a reliable planning environment for market actors, clear and credible criteria for a prioritisation of utilisation options are needed. Above all, this requires policy makers to clarify the hierarchy of policy objectives. From an economic point of view, prioritising bioenergy use according to climate change mitigation aspects would be preferable (Henke and Klepper, 2006; Isermeyer and Zimmer, 2006; SRU, 2007; WBGU, 2008). The contribution of bioenergy to energy security and rural value creation seems limited, or, in case of the latter, even uncertain (Berndes and Hansson, 2007), suggesting that other instruments than bioenergy support would be better suited to realize these aims. Moreover, a prioritisation of GHG mitigation allows for the use of synergetic effects with other aims; conversely, prioritising bioenergy uses according to energy security or rural development contributions could not guarantee reductions in GHG emissions. However, given the highly dynamic nature of the energy system transition, the GHG balances of different bioenergy pathways are by no means stable. For instance, while using biomass to substitute fossil fuels in the electricity sector constitutes a favourable GHG mitigation option under current conditions (cf. Sterner and Fritsche, 2011), this would change once renewable energies covered major shares of electricity demand. If bioenergy replaced other RES production, no GHG mitigation would be realised. In designing cross-sectoral bioenergy strategies, priority should therefore be given to pathways which a) provide favourable GHG balances under present conditions, and b) fulfil demands which are not likely to be met by other RES technologies at feasible costs in the foreseeable future. Examples for such applications are the provision of balancing power in the electricity system (cf. Fraunhofer-IWES et al. 2010), or the use of biofuels for heavy load road transport, shipping or aviation (IEA Bioenergy, 2009; WBGU, 2008).

For differentiating between bioenergy pathways according to GHG mitigation potential and costs, it seems prefarable to set signals for pathway optimisation at the utilisation stage, allowing them to propagate along the value chain. Evidently, a correct evaluation of pathways is of the utmost importance, highlighting the necessity of further improving Life Cycle Analysis research (Creutzig et al., 2012; Gawel, 2011). For allocation decisions further down the value chain, like choices of combustion and conversion technologies, feedstock and production practices, or sourcing decisions, the information handling advantages of markets should be used as much as possible; here, incomplete and asymmetrical information as well as rent-seeking increase the risk of government failure, if a detailed regulation of allocation decisions is attempted. Meanwhile, regarding the allocation between competing material and energetic biomass uses, it is important that the support mechanism remains flexible and allows markets to signal changing scarcity relations. Quantitative measures, such as biofuel quotas, create a largely price-inelastic bioenergy demand; as a result, there is a risk that the ability to pay for certain energetic uses may increase so much that other energetic and material demands are crowded out. Given the uncertainties about compliance costs and benefits of bioenergy support measures, price instruments offer a higher degree of control over the costs of bioenergy expansion and, correspondingly, its impacts on competing uses (cf. Pizer, 1999; Weitzman, 1974). Here, one option would be the cross-sectoral alignment of bioenergy support according to a simulated carbon price (well above current ETS price levels) (WBA, 2007), meaning that only bioenergy pathways with GHG mitigation costs below a certain level (taking potentials for technological progress into account) would receive targeted deployment support.[2]

However, given the multi-dimensionality of bioenergy's allocative problems, interventions further down the value chain may be necessary in addition to utilisation-side incentives. High potentials for innovation, for example, exist mainly for bioenergy conversion technologies (e.g. second and third generation biofuels), while combustion technologies are based on well-established processes (IEA Bioenergy, 2009). Accordingly, the question is whether deployment support for bioenergy combustion according to GHG balances, combined with R&D subsidies, is sufficient to encourage innovative conversion processes, or if further measures are necessary (e.g. the tightening of minimum GHG mitigation requirements over time, as implemented in the biofuel sustainability standards). Another point requiring further analysis is whether GHG-balance-oriented support would provide adequate incentives for developing "no regret" options, such as the integration of material and energetic uses, waste processing, or feedstock production on surplus land, and, if deemed necessary, how additional support could be designed. For a start, it is unclear how the categories of "surplus land" (cf. Dauber et al., 2012) and "wastes" should be defined (cf. COM, 2010c).[3] Furthermore, since using waste for bioenergy production already has definite cost advantages (cf. Ericson, 2009), additional support might overburden this source of biomass, given its relatively limited potential (cf. Chum et al. 2011).

Another area where a differentiation of bioenergy pathways beyond GHG characteristics remains necessary is the safeguarding of sustainable biomass production. Given the limited reach of EU regulation, binding utilisation-side support to mandatory certification constitutes a politically feasible approach for setting incentives for sustainable behaviour (Fritsche et al., 2010; Schubert and Blasch, 2010). However, it may be advantageous to limit mandatory certification to crucial criteria and proof of GHG-balance (as done in EU sustainability regulation), while extending its reach to all bioenergy carriers, in order to facilitate pathway differentiation. More comprehensive standards raise transaction costs, but cannot ensure sustainable production due to leakage effects (van Dam et al., 2010; Van Stappen et al., 2011). In fact, "overloaded" standards might even increase the risk of leakage, because incentives to reroute trade streams to regions with less stringent import regulations increase; also, certification

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[2] This approach could be extended to other RES, as long as future cost reductions from learning curve effects are taken into account. However, in the case of bioenergy, such a cross-sectoral alignment of support seems particularly urgent, because higher levels of bioenergy deployment increase competition for biomass resources, contributing to a trend of rising operating costs (cf. IWES et al. 2010).

[3] While the EU RED supports biofuels from wastes, residues, non-food cellulosic material, and ligno-cellulosic material by counting them double towards biofuel targets (COM, 2009, Article 21(2)), it contains no clear definitions of "wastes" and "residues" – instead, "these concepts should be interpreted in line with the objectives of the Directive" (COM, 2010c, p. 13).

with high transaction costs can discourage participation by smallholders (Beall, 2012). Overall, when indirect effects are taken into account, it seems impossible to guarantee that the EU demand for energetic feedstocks is met sustainably, without addressing the framework conditions of agricultural production in general (Frank et al., 2012). However, the necessary reforms remain up to national governance levels in producer countries; demand-side measures, like certification amendments and the introduction of ILUC factors (cf. COM, 2010b), do not solve this basic problem of regulatory jurisdiction. Under these conditions, it would be advisable to make use of the precautionary principle and avoid the creation of large additional, price-inelastic demands for biomass, while continuing to work on improving national framework conditions (e.g. through bilateral and international initiatives (Di Lucia, 2010)).

5. Conclusions

Overall, policy implications derived from a new institutional economics perspective differ considerably both from abstract neoclassical recommendations and the “muddling through” of actual bioenergy policy. Given the numerous risks of government failure in attempting to solve a highly complex allocative problem, it seems desirable to make use of markets as much as possible in downstream allocation decisions, while setting clear upstream incentives which can propagate down the value chain. For the coherence of the incentive framework and the efficiency of biomass utilisation, it is central that an unambiguous hierarchy between policy objectives is established. However, regulative interventions will need to be more numerous and diverse than envisioned by an “optimal” neoclassical internalisation approach, in order to adequately mitigate the effects of multiple interacting market failures and real world conditions, where the feasibility of solutions is limited by transaction costs and political considerations. For an “informed” bioenergy policy, it is necessary to move away from a mere quantitative expansion strategy, accompanied in places by measures to correct for sustainability risks. Instead, a clear identification of intervention points in the value chain is required, through which a qualitative differentiation of bioenergy support can be realized. Also, it is necessary to clarify the responsibilities of different governance levels and transparently discuss the limits of what EU sustainability regulation can achieve, at least in the short- to mid-term – ambitious uniform quantitative targets for biofuels should be reassessed in this light. Evidently, more research is needed concerning concrete second-, or third-best solutions which can be implemented in an imperfect world. For this, a NIE analysis of bioenergy governance options can make a valuable contribution.

However, if a public choice perspective is adopted, the questions arises what chances of implementation economic recommendations may have, even if they are based on more realistic assumptions than those of neoclassical theory (cf. Dietz and Vanderstraaten, 1992). If policy makers maximise voter and interest group support instead of general welfare, the prioritisation of GHG mitigation as a bioenergy policy aim is already contentious, and political activism in response to current topics of public concern becomes a rational strategy. This also opens the discussion, what role economic policy advice should fulfil under these circumstances, i.e. if the likelihood of finding political majorities should be explicitly included in the development of recommendations, or if economists should act as “lobbyists for efficiency” (Hahn, 2000 p. 395) and sustainability.

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