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Addressing uncertainty in decarbonisation policy mixes – Lessons learned from German and European bioenergy policy

Alexandra Purkus[a,*], Erik Gawel[a,b], Daniela Thrän[b,c,d]

[a] Helmholtz Centre for Environmental Research – UFZ, Department of Economics, Permoserstr. 15, 04318 Leipzig, Germany
[b] University of Leipzig, Institute for Infrastructure and Resources Management, Grimmaische Str. 12, 04109 Leipzig, Germany
[c] Helmholtz Centre for Environmental Research – UFZ, Department of Bioenergy, Permoserstr. 15, 04318 Leipzig, Germany
[d] DBFZ Deutsches Biomasseforschungszentrum, Torgauer Str. 116, 04347 Leipzig, Germany

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ABSTRACT

For promoting innovation in the context of sustainability transitions, research emphasizes the importance of combining technology-push and demand-pull instruments in a coordinated policy mix. Designing such policy mixes, however, remains challenging, due to path dependencies, interacting market failures, and uncertainty regarding eventual economic, environmental and societal impacts of innovations. This results in the need for a learning and flexible policy design, but simultaneously, stable political framework conditions are required to bring about lasting changes in production and consumption behaviour. This paper undertakes an economic assessment of how this trade-off between flexibility and stability has been addressed in practice, focussing on a case study of the European and German bioenergy policy mix which serves as a prime example for the challenges of dealing with uncertainty (e.g. regarding land use impacts, GHG balances, cost developments). Informed by the theory of second best, new institutional economics and the interdisciplinary policy mix literature, we identify dimensions for assessing whether relevant uncertainties, interactions between market failures and other constraints on first-best policy making have been handled in a rational manner. From the case study, we derive lessons for bioeconomy policy, as a further example of a decarbonisation policy mix faced by high uncertainty and complexity.

1. Introduction

Technological and social innovation is a key component of realising a decarbonisation of economic production, which is urgently needed to mitigate climate change. For promoting such innovation, empirical evidence highlights the importance of combining technology-push and demand-pull instruments in a coordinated policy mix [1–3]. The economic theory of second best emphasizes that under certain circumstances, a policy mix is called for to address a single policy aim such as greenhouse gas (GHG) mitigation [4–6]. First, this is the case if there are interactions between multiple market failures. For example, environmental externalities cause the demand for emissions-intensive technologies to be higher than socially optimal; this market failure is exacerbated by knowledge and learning spillovers which cause investments in research and development (R & D) but also the diffusion of innovative low carbon technologies to be lower than optimal [7,8]. Technological path dependencies further distort competition between such technologies and incumbent, fossil fuel-based options [9,10]. Second, it may not be feasible to implement "first-best" interventions which optimally address one market failure (e.g. emissions trading systems or carbon taxes which cause the full social costs of GHG emissions to be reflected in market prices), due to political and other constraints such as transaction costs, institutional path dependencies or uncertainty. The latter is particularly relevant in the decarbonisation context. Given the presence of ecological thresholds beyond which irreversible changes may occur, there is uncertainty about marginal damage costs of GHG emissions [11]. Also, there may be uncertainty about GHG balances of mitigation options, as in the case of bioenergy use [12], as well as about further environmental and social impacts. Under such circumstances, combining instruments which – imperfectly – internalize externalities (e.g. the European Emissions Trading System (EU-ETS) and R & D support) with further instruments to promote the diffusion of innovative low carbon technologies and safeguard sustainability can perform better than adopting a "one market failure – one instrument" approach [5,13–15].

The design of such "second-best" decarbonisation policy mixes, however, remains challenging. Uncertainties about eventual economic, environmental and societal impacts of innovative technologies result in

* Corresponding author.
E-mail address: alexandra.purkus@ufz.de (A. Purkus).

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the need for a learning policy design which provides flexibility to adapt to changing circumstances and new information [16–18]. Simultaneously, both innovation studies and economic policy literature stress the importance of stable political framework conditions for creating collective expectations regarding a path transition and incentivising lasting changes in production and consumption behaviour [1,19–21]. This is especially true if investments have long amortisation periods, like in the energy sector, and are highly asset specific in that their profitability depends on the continued existence of policy incentives [22,23]. Solving the trade-off between flexibility and stability therefore presents a key challenge for the design of innovation and transition policy mixes towards decarbonisation.

This paper analyses how this trade-off has been addressed in practice, focussing on a case study of the European and German bioenergy policy mix. Section 2 presents the methodology and theoretical background of the case study analysis. Building on an economic policy assessment framework, we draw on the theory of second best, new institutional economics and the interdisciplinary policy mix literature to identify relevant dimensions for assessing policy mixes in the presence of interacting market failures, uncertainty and other barriers to first-best policy interventions. Section 3 provides an overview of the German bioenergy policy mix in its European context. Section 4 evaluates this policy mix along the dimensions proposed in Section 2. Section 5 discusses what lessons can be learned from bioenergy policy for the design of bioeconomy policy, as an example of a further decarbonisation policy mix characterised by uncertainty and multiple interacting market failures. Section 6 concludes with a reflection on what insights can be drawn from the case study analysis for the design and evaluation of decarbonisation policy mixes.

Bioenergy policy has interesting insights to offer as a case study, because its development over the last decade serves as a prime example for the conundrum of dealing with uncertainty in policy design. On the EU level and in member states such as Germany, the use of bioenergy in transport, electricity and heating sectors has been associated with high expectations regarding contributions to aims such as GHG mitigation, security of energy supply and rural development [24,25]. Its expansion has been supported by the EU Renewable Energy Directive's 2020 targets for renewable energy sources (RES), which member states implement through a mix of technology-neutral instruments (e.g. carbon and energy taxes, EU-ETS) and technology-specific deployment support schemes, including biofuel quotas and incentives for bioelectricity and biomass-based heating technologies [26]. However, a critical debate ensued about direct and indirect land use change impacts of an increased biomass demand, associated negative environmental and socio-economic effects, uncertainties in assessing GHG balances, and high GHG mitigation costs of biofuels and dedicated bioelectricity pathways [for overviews, see Refs. [27,28–30]]. On the EU level, this led to the introduction of a cap on agricultural crop-based biofuels' contributions to the transport sector RES target, and continuing uncertainty about future biofuel policy design. In Germany, biofuel and bioelectricity support instruments were subject to a number of policy changes. In particular, remuneration rates for bioelectricity were significantly reduced in 2014 (see Section 3.2), following a debate on lower-than-expected decreases in electricity generation costs and the sustainability of energy crops [31,32]. Also, with increasingly high shares of the intermittent RES wind and photovoltaics, the systemic context of the energy transition has been changing. In sum, bioenergy policy has to deal not only with uncertainty regarding cost developments and environmental and socio-economic impacts of heterogeneous bioenergy pathways, but also with uncertainty about the future development of reference systems in relevant sectors (for example, an electricity system based on intermittent RES favours flexible bioelectricity plant concepts, rather than base load-oriented ones [33]).

Given these circumstances, a case study assessment of how bioenergy policy has performed in handling the trade-offs between policy stability and flexibility promises valuable lessons for decarbonisation policy mixes in contexts characterised by high uncertainty and complexity. An important example is the emerging field of bioeconomy policy [34–36]. Similar to bioenergy policy, substituting fossil resources in material applications for renewable ones is associated with various policy aims, but the heterogeneity of production pathways is even greater than in the bioenergy context, and there is a high degree of uncertainty about sustainable biomass availability and the performance of innovative technologies. As a choice of case study, the German bioenergy policy mix has been selected, because policy makers have pursued an ambitious expansion of bioenergy use in transport, electricity and heating sectors simultaneously, amplifying resource competition problems and coordination needs [37]. German policy instruments are embedded in the European policy context, illustrating the multi-level character of the policy problem, and increasing the comparability to other European member states.

2. Evaluating decarbonisation policy mixes in the presence of multiple market failures, uncertainty and other constraints: methodology and theoretical background

From a theoretical economic perspective, a policy mix should address market failures in such a way that the outcome is economically efficient, in order to achieve decarbonisation without using more societal resources than necessary. At the same time, it needs to be sustainable in a broader ecological and social sense – environmental "guard rails" [30] must not be exceeded, and distributive impacts need to be taken into account.

In reality, however, achieving efficiency and sustainability is complicated by several factors. First, there are conflicts between various societal aims to consider, including aims relating to efficiency, ecological and social sustainability dimensions. Second, interactions between multiple market failures have to be taken into account, as well as constraints which prevent the implementation of first-best solutions (see Section 1). Third, the political process follows its own inherent rationality, and policy aim setting and instrument choices are influenced by the pursuit of variables such as political support or administrative budgets [38,39]. In particular, in a democratic setting, policies require political majorities to be adopted, and the necessity of building broad advocacy coalitions and addressing different interests may imply trade-offs between economic efficiency and political feasibility.

To reflect these conditions of real-world policy making, we assess whether policies succeed in handling conflicts between aims, interactions between market failures, uncertainty and other constraints in a "rational" manner, while striving for efficient and sustainable outcomes [31]. This approach is informed by second-best thinking [4–6], and can be operationalized through assessment dimensions derived from the interdisciplinary policy mix literature and new institutional economic theory. The question here is what policy mix characteristics contribute to efficiency and sustainability [40], even if optimal outcomes where all relevant market failures are addressed by first-best interventions prove unattainable. Furthermore, conditions for second-best optima may remain unknown due to the complexity of the policy problem, and the position of sustainability guard rails may be uncertain. Relevant policy mix characteristics can be distinguished according to whether they refer to the setting of policy aims, the alignment of aims and measures, or the choice and design of policy instruments (see Table 1).

2.1. Defining a system of policy aims

Sustainability and economic rationality requirements imply that a system of policy aims should be complete and consistent [41]. Completeness means that it should encompass all economic, social and environmental aims that are relevant in a given policy context (e.g. bioenergy policy), to be able to reflect synergies and trade-offs. Consistency requires aims not to contradict each other; if conflicts arise, a prioritisation is necessary to indicate how trade-offs are to be resolved.