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Conceptual and empirical advances in analysing policy mixes for energy transitions

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ABSTRACT

Energy transitions face multiple barriers, lock-in, path dependencies and resistance to change which require strategic policy efforts to be overcome. In this regard, it has been increasingly recognised that a multiplicity of instruments – or instrument mixes – are needed to foster low-carbon transitions. In addition, over the past few years a broader conceptualization of policy mixes for sustainability transitions has emerged which we adopt in this special issue. Such a broader perspective not only examines the interaction of instruments, but also captures corresponding policy strategies with their long-term targets and pays greater attention to the associated policy processes. It also encompasses the analysis of overarching policy mix characteristics such as consistency, coherence or credibility, as well as policy design considerations. Furthermore, it embraces the analysis of actors and institutions involved in developing and implementing such policy mixes. To explicitly consider these further aspects of policy mixes, this special issue includes fifteen papers with different analytical perspectives drawing on a range of social science disciplines, such as environmental economics, innovation studies and policy sciences. It is our hope that the conceptual and empirical advances presented here will stimulate diverse future research and inform policy advice on policy mixes for energy transitions.

1. The importance of policy mixes for energy transitions

The Paris Agreement calls for the rapid decarbonisation of the global energy system to limit temperature increases to well below 2 °C. Since fossil fuel use in the energy sector is one of the main contributors to global carbon emissions, achieving this goal requires a global transition away from carbon-intensive energy systems towards low carbon configurations. Such transitions can be understood as dynamic processes of structural change in the way energy is produced and used, and have historically taken place over long-time horizons [1–3].

Over the last 15 years a burgeoning, interdisciplinary literature has developed on how such transitions occur [4,2,5–10]. The sustainability transitions literature conceptualises transitions as co-evolutionary processes that involve technological innovations and their use in societal applications. As such, transitions are multi-actor processes, involving a large variety of social groups. They are characterized by radical shifts from one socio-technical configuration to another; and are often long-term processes taking several decades ([3,91]).

This is because transitions face multiple barriers, including lock-in into high carbon, fossil fuel based technological trajectories, path dependencies and resistance to change from incumbent industries benefitting from the current socio-technical configurations. For example Unruh [11] has powerfully argued how industrial economies have been locked into fossil fuels based energy systems through a process of technological and institutional co-evolution which is driven by path dependent increasing returns to scale. One form of path dependency is cognitive lock in as firms normally continue innovating along established paths ('normal' problem solving) rather than trying something radically new (technologies or business models). This process has been described as technological trajectories [12] which are hard to shift. Also Walker [13] has shown that organisational commitments and vested interests in the continuation of systems, even when economically obsolete, can create inertia, causing inferior technologies and technology paths to survive. These obstacles mean that low carbon transitions require strategic policy efforts to be overcome [14,15]. Without such policies, these problems enforce the stability of existing unsustainable, high carbon energy systems and prevent transitions from occurring [11,5].

Public policy is hence key to promoting energy transitions in terms of both their speed and direction [5,16,7,17]. While much of the early

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literature on addressing climate change focused on discussions about specific instruments suitable for internalising negative externalities arising from greenhouse gas emissions (tax versus trading) [18,19], it has been increasingly recognised that a multiplicity of instruments is needed to foster successful transitions [20–22].

This shift away from striving for one instrument as the silver bullet to a recognition that well designed combinations of instruments are needed for fostering transitions may still be contested by some. Yet, even economists increasingly acknowledge that tackling climate change may require not only carbon pricing but also complementary instruments [23]. Empirically, even in jurisdiction where an emission trading system (ETS) as one way of pricing carbon has been introduced (such as in the EU), alongside this policy instrument a wide range of other instruments exist, thereby addressing several market and system failures. For example, the progress of the German electricity transition towards renewable energies, arguably largely hinged upon a policy design which combined feed-in tariffs and priority access to the grid, as well as specific long-term expansion targets, under the umbrella of one law, the EEG, thereby complementing the EU ETS [24–26]. This example also illustrates that other policy mix considerations played a key role, as well, such as the simultaneous existence of the nuclear phase out, the promotion of research and development, or the credibility, consistency and coherence of the overarching policy mix [27,24,28]. That is, while some instruments may be considered as core, such as feed-in tariffs for the promotion of renewable energies or carbon pricing for reducing greenhouse gas emissions, what matters for achieving the objectives associated with ambitious low-carbon energy transitions is not only their design but how well they are embedded in a policy mix [29].

Furthermore, any attempt to govern energy transitions does not start on a bare slate but is always embedded in pre-existing policy contexts with legacies of instruments from earlier policy eras still in place [30]. It is this complicated, messy reality which influences policy outcomes rather than economic textbook considerations around ‘first best’ policy options and ‘optimal’ policy design. The policy mix literature is an attempt to make sense of this empirical complexity while simultaneously acknowledging a diverse set of policy rationales calling for policy mixes rather than single policy instruments. It is therefore increasingly important to explicitly study policy mixes, how they can be designed and how they can be implemented in order to promote deliberate sustainability transitions [31,29].

Various definitions for such policy mixes exist (see Table 1), with the most basic ones focusing simply on a number of multiple policy instruments and how they are combined in instrument mixes [32,20,23]. Correspondingly, much of the research on policy mixes for important sustainability areas such as energy transitions has so far mainly focused on the analysis of interactions of policy instruments designed to affect the operation of energy systems [35–38]. However, broader understandings of policy mixes pay greater attention to other aspects of such mixes as well, especially those related to policy processes and how they affect the characteristics of policy mixes, including such issues as policy integration and coordination across multiple sectors and levels of government ([39,29,40,92]).

However, given its novelty, empirical applications and analyses applying such extended policy mix conceptions have so far been limited [28,41,42]. It is therefore the aim of this special issue to collect emerging conceptual and empirical advances adopting such a broader conceptualization of policy mixes in order to study and assess the means and mechanisms for energy transitions. The special issues thus includes papers examining not only interacting instruments, but also corresponding policy strategies and their long-term targets, policy processes as well as overarching policy mix characteristics such as consistency, coherence or credibility and policy design considerations. In addition, the special issue engages with the analysis of the actors and institutions involved in developing and implementing such mixes in the energy case. Consequently, the analytical perspectives in this special issue draw on a range of social science disciplines, such as environmental economics, innovation studies and policy sciences to explicitly consider further aspects of such policy mixes. These different perspectives on policy mixes will be briefly introduced in the next section.

2. Disciplinary perspectives on policy mixes

The emerging literature on policy mixes for sustainability transitions builds on three key disciplinary foundations: environmental economics, innovation studies, and policy sciences. Unfortunately, these three fields have so far developed largely independently of each other, with little attempts of cross-fertilization. As a consequence, each has developed its own understanding of what constitutes a policy mix and how key terms should be defined, thereby rendering interdisciplinary dialogue difficult (see Table 1 and Fig. 1).

Table 1
Three main fields addressing policy mixes with exemplary definitions.

Field	Examples of policy mix definitions
Environmental economics	• Instrument mixes are defined as a situation in which “several – instead of one – policy instruments are used to address a particular environmental problem”. ([32], p. 186) • “The need for a policy mix has been recognised by many governments, but experience to date has been that the interactions among multiple policies are often not well understood nor well coordinated, which can lead to policy redundancy or policies undermining one another, reducing the effectiveness and efficiency of the overall package.” ([20], p. 60) • “Polluting sources may be affected directly or indirectly by several policies addressing the same pollution problem. This is referred to as a policy mix [..].” ([23], p. 1)
Policy sciences	• Limitations in environmental policy “can only be overcome by invoking a broader vision of regulation and by the pursuit of broader policy mixes, utilizing combinations of instruments and actors, and taking advantage of various synergies and complementarities between them." ([33], p. 5) • “Policy mixes are complex arrangements of multiple goals and means which, in many cases, have developed incrementally over many years.” ([30], p. 395)
Innovation studies	• “A policy mix is defined as: The combination of policy instruments, which interact to influence the quantity and quality of R & D investments in public and private sectors.” ([34], p. 3) • “[..] policy mixes favourable to sustainability transitions need to involve both policies aiming for the ‘creation’ of new and for ‘destroying’ (or withdrawing support for) the old.” ([31], p. 206) • “[..] we define the policy mix as a combination of the three building blocks elements, processes and characteristics, which can be specified using different dimensions. Elements comprise the (i) policy strategy with its objectives and principal plans for achieving them and (ii) the instrument mix with its interacting policy instruments. The content of these elements is an outcome of policy processes. Both elements and processes can be described by their characteristics, including the consistency of elements, the coherence of processes, as well as the credibility and comprehensiveness of a policy mix. Finally, the policy mix can be delineated by several dimensions, including policy field, governance level, geography and time.” ([29], p. 1622f.)