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Climate policy innovation: a socio-technical transitions perspective

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Abstract

Seeking to develop a novel understanding of how climate policy innovations emerge and spread, we conceptualize three types of CPIs – genuinely original, diffusion based and reframing based – and relate these to the socio-technical transitions literature, particularly the multi-level perspective that explains change through interaction between 'niche', 'regime' and 'landscape' levels. Selected climate-related transport policies in Finland, Sweden and the United Kingdom are used to illustrate five hypotheses that connect these concepts from the multi-level perspective to particular types of climate policy innovation. 'Original' policy innovation may be uncommon in contexts with major sunk investments such as transport, principally because socio-technical regimes tend to be resistant to political pressures for change originating at the same level. Nonetheless, the Multi-level Perspective posits that regimes are subject to influence by pressures originating at both niche and landscape levels. Given that policy reframing is relatively common, it may offer a key entry point for climate policy innovation in the short to medium term.

Keywords

Climate policy innovation, socio-technical transitions, path dependence, path creation, transport

Introduction

Facilitating politically acceptable forms of climate policy innovation (CPI) is increasingly urgent, and because climate change is perceived as such a 'grand challenge', the need will be on-going for many years. Interest in finding new approaches to policy also reflects the lack of political support for tightening existing policy instruments to achieve further mitigation of climate change. Because it is among the largest carbon dioxide (CO_2) emitting sectors globally, transport is a major problem for emissions reduction. In the European Environment Agency (EEA), emissions of greenhouse gases (GHGs) from transport (excluding international air and maritime transport emissions) increased by 25% between 1990 and 2008, and transport was responsible for 20% of total EU-27 GHG emissions in 2011 (EEA 2011, 2013a). Relative to a 1990 baseline, EU-27 GHG emissions as a whole decreased by 18.4%, with all main emitting sectors except transport and production and consumption of fluorinated gases experiencing declines (EEA 2013a). Land transport is not yet covered by the European Union (EU) emissions trading scheme. Moreover, given slow progress on voluntary agreements to reduce CO_2 emissions from passenger cars and the political complications in achieving mandatory regulation (Euractiv 2013), there is a pressing need to find forms of policy acceptable to key interests. Recently, the dominance of and change-related pressures on automobility (e.g. Geels *et al*. 2012), including the development of alternative fuels (e.g. Hillman and Sanden 2008), have attracted attention in the socio-technical sustainability transitions literature. Despite this, a connection between policy innovations and transitions has not yet been made.

Given this, we have two aims here: first, to clarify the concept of CPI – what it means more specifically and what types of CPIs there are – and, second, to suggest hypotheses regarding the interlinked dynamics of CPIs and socio-technical systems. These hypotheses are not viewed as comprehensive: alternative or broader country and policy case selection may well add substantial nuance and further hypotheses. We proceed by a process of case-based, theory building (Eisenhardt and Graebner 2007) with purposive case selection (Seawright and Gerring 2007) rather than hypothesis testing.

One of the key issues at stake is the extent to which the relatively structuralist accounts of change provided by socio-technical transitions thinking can inform an understanding of CPI, particularly one that distinguishes alternative types of such innovation. Another issue involves how 'policy' is addressed in transitions research. While the need for supportive policies has been emphasised (Smith *et al*. 2005), the transitions literature has been criticised for treating policy and politics as exogenous (Meadowcroft 2011). Our premise is that there is merit in exploring the potential for synergies between different forms of CPI and socio-technical transitions concepts, principally because there are often obvious associations between the path dependencies that both policy (Pierson 2004) and socio-technical systems (Arthur 1989, Unruh 2000) exhibit. Moreover, policy change is interwoven in and dependent on the stability and instability of socio-technical regimes that policies aim to influence. The cases that we consider bear this out, with economic, technological and psychological investments influencing the development of policy.

In our discussion, first we develop a heuristic, threefold CPI typology. We then bring these together with selected transitions concepts to form hypotheses for discussion. Thereafter we explain the methodological approach used for case-based theory building and present illustrative examples, followed by discussion of the linkages between CPI and transitions. Overall, the purpose is to explore and illustrate new ways of thinking about CPI, specifically as informed by the multi-level perspective from socio-technical transitions thinking. While there seems to be little work in this vein, we connect to work by Hildén (2014), who makes use of the multi-level perspective as part of an account of how policy evaluation can become a part of political struggle as policy evolves.

Theoretical approach: linking CPI and socio-technical change

Defining CPI

When defining CPI, we largely concur with the approach of Jordan and Huitema (2014), except that for present purposes we focus on policy, rather than policy impact, and we give more attention to the reframing of policy in addition to policy innovation and diffusion. We specifically focus on the purpose of policy, acknowledging Lundqvist's (1996) categorisations of environmental policy as based on function, institution or purpose. We define climate policy specifically as policy with a principal purpose, or with one of the key purposes, to mitigate or adapt to climate change. In the empirical cases explored below, our focus is limited to mitigation. While climate policies may be formed and implemented at all levels from the local to the global, here we focus on national policy. It should be noted that the policy databases used do not include local-level policies and that we envisage plenty of scope for future consideration of the implications of other policy cases and countries. Our discussion connects particularly to the first two elements of the ‘innovation triangle’ (invention, adoption/diffusion, impact) set out by Jordan and Huitema.

In the policy innovation literature, it has been acknowledged that the term 'policy innovation' is used rather loosely, sometimes referring to mere policy change (e.g. Black 2005). Yet a closer look at other innovation literatures reminds us that innovation can be viewed as more than simply change. In an economic context, the definition of the term ‘innovation’ most referred to can be traced back to Joseph Schumpeter (1935, p.4), who introduced it as ‘changes in production functions which cannot be decomposed into infinitesimal steps’. Technology innovations have traditionally been characterised as incremental, pushing the existing technological trajectory for an existing system and linking mechanisms (Tushman and Smith 2004), or radical, discontinuous innovations, breaking system boundaries (cf. Garcia and Calantone 2002).

One can distinguish between policy processes and outputs of these processes, such as agreed goals, strategies or policy instruments. Although the concept of policy innovations may refer to both processes and their outputs (as in the case of innovations of technology (Nonaka and Peltokorpi 2006)), our focus is solely on outputs, namely on policy innovations related to general goals, to strategies and, particularly, to policy instruments. In the empirical context, we interpret policy innovations as adopted policy instruments that have one or several new components, such as a new goal, new type of leverage mechanism, new implementing organisation or a new policy target group.

With the above in mind, we distinguish three types of policy innovation - original, diffusion-based and reframing-based – while acknowledging the overlaps with but also differences from Jordan and Huitema

(2014). These are treated as heuristic categories in that each relates to a tendency, with the border between categories being somewhat flexible, and with a given policy having some degree of multiple category membership (Zadeh 1965). Often, innovation is considered as what is new for a given country or policy domain (Black 2005). Here, we propose that the context of what we term an *original* policy innovation should be global, i.e. the first application of a 'policy invention' (cf. Jordan and Huitema 2014) anywhere and in any sector. This then raises the question of at what stage policy is judged to be original, an empirically determined matter in each case. While examples of original climate policy innovation in transport appear few in the databases searched for this study, possible original policy innovations can be detected in regional transport policy, including for example, initial instances of high priority bus corridors and congestion charging (see e.g. Marsden *et al*. 2011).

Accordingly, we suggest that *diffusion-based* CPI refers to policy innovations that are new to climate policy in the given country or jurisdiction (i.e. geographically diffused), or new to the climate policy domain though not necessarily for the country per se (i.e. sectorally diffused). When policies are adopted in new countries or new policy domains, typically some modifications need to be made to take into account the national constitution, culture and societal structure, or the specificities of the sectors that the policies address. Thus, the definitional problem involves determining at what point any modification becomes so large that the policy innovation can be judged ‘original’.

Reframing-based CPI refers to cases in which existing policies have been justified or re-named in a new way. An example of a reframing-based CPI is the inclusion of annual energy tax increases as climate policy, when these are already instituted for fiscal reasons. As observed by Haug *et al*. (2010), several long-standing measures reported as climate policies were initially designed as responses to other problems. At a strategic level, a level above that of policy instruments, support for many energy technologies has been reframed as climate policy without significant change at the level of policy instruments (Lovell *et al*. 2009, Kivimaa and Mickwitz 2011). In the long term, however, reframing may lead to other types of policy innovation. Reframing may involve an element of diffusion but it denotes more than this, specifically relating to pre-existing policy that is given an additional or new rationale.

We should also note that some CPIs may go undetected with sometimes radical modifications to policy instruments or the processes behind them being obscured, e.g. if the policy instrument name stays the same and changes are not widely advertised. Thus a tax may be renewed from being merely fiscal to taking into account environmental effects in a novel way. Moreover, the extent to which a policy innovation results in innovations in socio-technical systems is not simply dependent on the degree of innovativeness in the policy as such.

Socio-technical change dynamics as an object of policy analysis

The processes we are concerned with here are those of co-evolution: the notion that policy innovation and socio-technical change exist in a dialectical relationship, in which either may act as first cause (Nelson and Winter 1982). Understanding policy innovation may be furthered by understanding socio-technical change and - in particular – by understanding how the two relate. To discuss the value of transitions thinking for theorizing CPI and vice versa, we draw on transition frameworks, most notably the *Multi-Level Perspective* (MLP), which understands transitions as outcomes of alignments between developments at multiple levels of the socio-technical system (Geels and Schot 2007). Geels and Schot (2007) provide an overview of MLP thinking that distinguishes three levels of heuristic, analytical concepts: niche innovations, sociotechnical regimes and the sociotechnical landscape.

Overall, the multi-level perspective argues that transitions come about through different types of interaction between processes at the three levels, via niche-protected innovations gradually becoming more powerful, landscape-level change that pressures the socio-technical regime, and destabilisation of the regime enabling niche-innovations to gain their own momentum (Geels and Schot 2007). At the micro-level, technological niches are conceived as the location at which path-breaking innovations emerge. In terms of the original evolutionary (ecological) metaphor, they are akin to genetic novelty or diversity that may or may not develop further and that the niches act to protect (if only temporarily) the novelties involved (Kemp *et al.* 1998). Niches are protected spaces to which policies may passively or actively provide protection, nurturing, empowerment (Smith and Raven 2012) - or hindrance. In transport, examples of niches include inter-modal travel, buses running on alternative fuels and personalised travel planning (Geels 2012). Routinised practices and cognitive processes relating to the dominant socio-technical regime are considered important reproducers of that regime (Nelson and Winter 1982) and need to be transformed by niche or landscape pressure if system change is an objective.

At the macro-level, the *sociotechnical landscape* is conceived of as an exogenous environment that is beyond the direct influence of niche and regime actors, including macro-economics, deep cultural patterns and macro-political trends (Geels and Schot 2007). This said, there is no definitive means of allocating a given factor to a given level in these perspectives. Indeed, the positioning of government policies in the MLP is somewhat unclear, or at least variable: policy has been viewed as contributing to niche-level developments (Smith and Raven 2012) but has also been referred to in the context of normatively-driven macro-level processes that relate to drivers of change originating within the regime level, as well as political settings of the landscape level (Berkhout *et al*. 2004). Here we adopt the proposition that policies specific to the regime relate to regime-level stability and change (such as transport policies for transport systems), while horizontal top-level policies and policies from other domains are part of the landscape level (such as overall climate policy agreements and targets or land use policies influencing the development of the transport system).

The concept of regime, too, functions heuristically in transitions theory, with a broad definition. Geels (2004, p. 905) defines the socio-technical regime as: 'the "deep structure" or grammar of ST-systems, […] carried by the social groups'. In this case the regime is the complex of interconnected social and technological phenomena directly relating to and reproductive of fossil fuel-based transport. This regime is sustained by the beliefs, perceptions and practices of actors, such as transport planners and car manufacturers, sunk investments in infrastructure and skills, life styles and cultural practices built around automobility (Geels 2012). The socio-technical transitions literature also conceives of alternative pathways that systems of production may take, including transformation, reconfiguration, technological substitution, de-alignment and re-alignment (Geels and Schot 2007).

Hypotheses

Overall, we hypothesise that policy innovation is reflected differently in the three levels of MLP. At each level and also between levels, there are mutually-influencing relationships between socio-technical systems and policy innovation and change. Firstly, the major impact of the *landscape level* is as a creator of pressures for CPI, expressed in the development of new global, general level policy goals, strategies or instruments. The *regime level*, such as the fossil-fuel based transport regime, is likely to be the main locus of sectoral and more specific CPI, while simultaneously most strongly tied to path dependence and vested interests, making it more difficult for policy innovations to become adopted. The *niche level* can be depicted as consisting of small platforms for CPI, with new technologies and solutions making new policies possible, through demonstrating or testing policy inventions and innovations at small scales, but also through showing initially whether policy innovations are likely to have impacts on socio-technical systems. As here the empirical focus is on transport-specific CPI, the policy examples do not reflect landscape level CPI but rather regime and niche level CPI.

Accordingly, we posit a number of hypotheses for discussion through illustrative cases of climate policy influencing land-based passenger transport in three EU member states: Finland, Sweden and the UK. The hypotheses are consistent with the over-arching premise that socio-technical regimes are highly resistant to original CPI, that they are more likely to be affected by policy innovations and pressures arising out of niche and landscape level pressures, and that a key consequence of this is that policy reframing and diffusion are more common than policy originality.

H1 *Regime-level policies are more resistant to innovation by actors in that regime than those operating at macro and micro levels and also in different regimes.* This hypothesis posits that policy innovation (often of a diffused type) is more likely to originate at the landscape (macro) level, making use of niche-level (micro) experience and learning.

H2 *CPI that seeks to reduce demand absolutely is rare and policies supporting technical substitution options are favoured*. This hypothesis follows in part from the dynamics posited in H1, namely resistance to policy innovation that impinges on regime-level actors.

H3 *CPIs supportive of technical substitution options are themselves supported by a range of existing institutions, sectoral networks and policy instruments.* Regimes consist of interconnected, shared modes of thought and practice. Those that emerge through the political process tend to be those that easily mesh with existing institutions in all senses. While disruptive technologies may also be supported by existing institutions, the extent of support by formal and informal institutions is likely to be lower unless there are benefits to the regime's key actors. Such support is likely to be lower still for pro-behaviour change actors, who have less political and hence institutional support.

H4 CPIs that successfully support incremental socio-technical system change may subsequently result in several mutually supportive processes leading to wider regime level change, facilitated by re-organisation of policy processes and changes in industrial sectors and their business foci. These changes may be incentivised via policy bundles that address both technology supply and demand, such as national innovation policies supporting particular research and development (R&D), which in turn catalyse and subsidise commercial R&D, and which are also supported by related environmental targets.

H5 Reframing-based CPI reflects change in the landscape pressure on the socio-technical system, and is more likely to be supported by existing regime actors when reframing is carried out to the net benefit of the more powerful, incumbent actors. This hypothesis suggests that climate policy tends to be implemented so as to achieve energy security and economic competitiveness ends, with measures taken to support technological niches, while leaving the economic competitiveness of incumbents relatively uncompromised.

Research approach, methods and cases

Empirically we focus on CO_2 emissions from land-based passenger transport which are the product of the distance travelled as passenger-km, the transport mode as vehicle-km per passenger-km, the fuel efficiency of the vehicles, and the carbon content of the fuel (Monni and Raes 2008). To explore related policy innovation further, we select a small number of examples of CPI at instrument level, with the objective of discussing the utility of selected socio-technical transitions concepts in understanding policy innovation. The policy-example selection is made so as to permit: cross-comparison between three member states (selection of biofuel-related policies); inclusion of different types of policies (regulation, economic and informational instruments); and discussion of the examples in relation to the hypotheses.

The small set of policies examined is scoped down from a long-list compiled from IEA and EEA databases dealing with climate policies for transport (as defined by the reporting countries).[1] From the long-list we have selected EU and national level climate-related policy instruments within the transport sector (Table 1). Policies in italics are explored in more detail below. The initial screening of the databases was carried out in 2011, with examples selected on this basis. Table 1 reflects the situation in late 2013 and includes instruments such as deployment subsidies for electric or low carbon vehicles that were not present two years earlier; the classification of policies as original, diffused or reframed is in accordance with the definitions above.

INSERT TABLE 1 HERE.

[1] The EEA database includes policies and measures reported by EU Member States to the Commission or under the UNFCCC (EEA 2013b). The IEA Policies and Measures Databases offer access to information on energy-related policies and measures taken or planned to reduce greenhouse gas emissions, improve energy efficiency and support renewable energy development and deployment (IEA 2013).

Original CPI in transport: eco-driving

As noted above, in practice there is no unambiguous boundary between a policy innovation that is original and one that is diffused from another country or policy domain, not least because policies are typically modified, often greatly, in national applications. Strictly viewed, original CPI is largely absent in national transport policy in the examined countries based on the databases studied in 2011 and re-reviewed in 2013, while both Sweden and the UK demonstrate more localised examples of innovative approach to transport policy (see e.g. Marsden *et al*., 2011).

Diffused CPI in transport

In the cases examined here, diffused CPI, i.e. policy processes or instruments that have been adapted from other countries or from other policy domains, appears to be the most common type of CPI. Examples include energy labels for cars (EU) originally designed for white goods; voluntary energy efficiency agreements with car manufacturers (Sweden) or with public transport organisations (Finland), that were originally designed for energy-intensive industries; CO_2-based vehicle excise duties and annual vehicle taxes (Finland) adapted from energy taxation; mandatory training in eco-driving (Sweden), an extension of safety training in freight transport; and the biofuels distribution obligation initially applied in Brazil.

Finnish voluntary agreements

Voluntary agreements in energy saving and energy efficiency have been defined as *'tailor-made negotiated covenants between the public authorities and individual firms, which include targets and timetables for action aimed at improving energy efficiency or reducing GHG emissions and define rewards and penalties'* (Rezessy and Bertoldi 2011, p. 7121). The scope of the agreements defines their intended impact on the socio-technical system and, because they are voluntary, they have often been acceptable to different interest groups. While voluntary agreements are today used to implement the Energy Services Directive 2006/32/EC, which could be viewed as landscape pressure on member states, most voluntary agreements in the EU were introduced before relevant directives entered into force.

The first voluntary energy saving agreements were signed in Finland in the early 1990s; the approach was expanded in 1997 when central industrial lobby organisations decided to join. The first agreement with the public transport sector was signed in 2001, concerning older buses and coaches, and replaced by a wider agreement in 2005, including also local rail transport providers. The latest agreement (2008-2016) was signed in 2008 and differed from earlier agreements in that elements of continuous improvement and monitoring of energy consumption were added. The current agreement includes a goal of 9% improvement in energy efficiency by 2016 (Government Bill 111/2009), targeted at established regime actors. While the two main sector associations, significant regime actors, are signatories to the energy saving and energy efficiency agreements, it has been difficult to achieve the set target for the latest agreement, whose larger demands for monitoring and reporting have deterred company-level actors from joining.

In general, voluntary energy-efficiency agreements have been a favoured policy instrument in Finland, primarily because they are incremental in that they target the efficiency of vehicles and fuel use. While they may spur substantial changes in the behaviour of actors, this is not assured: small transport companies may be unresponsive to customer interest in energy efficiency, may not have financial resources for demanding energy efficiency investments, and the implementation of energy-efficiency technology and practice is dependent on the on-going economic development of business sectors utilizing freight transport (Liimatainen *et al.* 2012), i.e. established actors in interlinking regimes.

EU Biofuels Directive

Biofuel policy in European member states has been driven by the Biofuels Directive (2003/30/EC), requiring that ‘biofuels or other renewable fuels’ constitute 5.75% of the energy content of petrol and diesel sold for transport by 2010. In 2008, this was modified to a 5% share by 2015 and 10% by 2020, conditional on at least 20% of the 2015 target and 40% of the 2020 goal being met from ‘non-food and feed-competing’ second-generation biofuels, or from other renewable fuels such as renewably-sourced electricity and hydrogen.

Despite environmental and social concerns related to managing biofuel production (Upham *et al.* 2011), current biofuel policy might be considered the leading edge of a shift to a more materially substantive bio-economy, in which biological productivity is brought into technological use to a greater extent. Increasing biofuel blends and, following this, an increased need for fuel sources and modes of biomass production, will require changes in interlinked socio-technical regimes – such as agriculture or forestry, and energy - and the biomass-based economy. The socio-technical field is thus of rapidly increasing interest not only to energy incumbents, but also to the agricultural and forest sectors. In this respect, although a form of diffusion-based CPI, biofuel policy also represents a reframing of agricultural policy in terms of mainstreamed climate policy on the EU level, which partly explains the extent of cross-regime support.

Distribution obligations were one essential policy instrument through which Brazil achieved a transition to an ethanol based transport system (Maroun and Schaeffer 2012).

UK implementation of the biofuels directive

Under the Renewable Transport Fuel Obligations Order 2007 and its amendments, the Renewable Transport Fuels Obligation (RTFO) implements the EU biofuels distribution obligation in the UK via a system of tradable certificates – itself an approach diffused from other policy sectors - that must now conform with conditions specified in the Renewable Energy Directive (2009/28/EC). The RTFO has been strongly opposed by a coalition of cross-regime actors, environment and development NGOs since its inception, on the grounds of inadequate precaution with respect to environmental and social protection (Upham *et al.* 2011). Key to this has been the vexed issue of indirect land use change, with its substantial management and measurement problems, particularly the question of whether a certificate-based management system can adequately protect against second and subsequent order impacts.

Influential supporters of the RTFO have included dominant transport regime actors, notably the Department for Transport and commercial members of the Low Carbon Vehicle Partnership, a multi-sector network established by government (Anable 2009). Following the ‘Gallagher review on the potential indirect land use effects of biofuels policy’ (Renewable Fuels Agency 2008), a reduced rate of increase in the targets for biofuel supply was adopted in the UK (Renewable Fuels Agency 2009). Nonetheless, the original European Commission (EC) target of 5% biofuel supply by volume was retained. The implementation of the EU biofuels distribution obligation in the UK under the RTFO has used sustainability and carbon assessment embodied in existing voluntary certification schemes, an approach now adopted at EC level and diffused from the Netherlands. Unlike Sweden, in the UK prior to 2007 there was little legislative support for biofuels.

Reframing-based CPI in transport

Reframing-based CPI refers to a process in which a new, climate-related objective has been added to justify or strengthen an old policy, or to a situation in which the process has been changed to include climate objectives, resulting in an incremental need for modification of existing policies. Annual fuel duty increases, for example, are portrayed in the EEA/IEA listings by the UK as climate policy, while the Fuel Duty Escalator was already described as a transport demand instrument in 1992 (Potter 2009). Similarly the reduction of speed limits has been presented as climate policy in Sweden, reframed as a dual policy instrument found to

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improve both traffic safety and reduce greenhouse gas emissions under certain conditions. Both of the above policies are typically strongly opposed by existing regime-level interest groups, particularly car owners (Cass 2006).

Subsidies for alternative transport fuels in Sweden

Transport fuel-related changes have been targeted in Swedish energy policy since 1975. In the 1970s and 1980s, subsidies for alternative motor fuels were motivated by the need to break oil dependence to support industrial production and national security (Government bill 1975; 1981). In 1975, R&D programmes were introduced that addressed the development and - later - the demonstration of alternative motor fuels. Methanol was promoted by a dominant transport regime actor, Swedish carmaker Volvo (Ulmanen *et al.* 2009), who, in a niche building attempt, co-founded with the government the Swedish Methanol Development Company (SMAB). By the mid-1980s, landscape influences, lower oil prices and reduced threats from the cold war reduced the drive to alternative fuels (Sandén and Jonasson 2005). Yet, the 1980s witnessed an exemption on fuel tax for alcohols, large-scale subsidised trials of ethanol production involving the Federation for Swedish Farmers (SLR), and trials with forest industry by-products (Sandén and Jonasson 2005). A subsidy supporting ethanol production from cereals was introduced in 1991 largely in response to deregulating the agricultural regime and a search for new markets for agricultural products (Söderberg 2005).

Following landscape-level pressure from climate change and international policy, climate-based reframing of Swedish biofuel subsidies took place through a revision of energy policy in 1997 (Government bill 1996/97, p. 84), in which energy R&D was conceived of as having a vital role in reducing CO_2 emissions from transport. Increased government funding on energy research was proposed to further develop and introduce near market technologies from several alternative niches (e.g. fuel cells, gasification of biomass, energy crops) (Government bill 1996/97:84). In the late 1990s, the government provided financial support for additional fuel-flexible vehicles and filling stations via Local Investment Programs for municipalities (Sandén and Jonasson 2005). In 2009, another major reframing took place as the Parliament approved a new Climate and Energy Strategy. The long-term ambition is that vehicles in Sweden should be independent of fossil fuels by 2030 (Government bill 2008/09:162).

Transport biofuel subsidies in Finland

Finnish transport biofuel policy is relatively new and, besides temporary tax relief on experiments (Government Bill 231/2006), emerged as a response to the EU directive. Transport biofuels were politically ignored until around 2005 due to strong advocacy coalitions from industrial and energy regimes determining other uses for domestic biomass. Despite a Finnish oil company producing biofuel products – a small niche level action - already in the 1990s, there was little interest among others, partly because the Finnish agricultural lobby did not push for transport biofuels (Lovio and Kivimaa 2012). Finland initially opposed the EU Directive and justified its low national target for 2005 (0.1%) on the grounds of limited national resources (Government Bill 231/2006).

In Finland, implementation of the biofuels directive was complemented by a reframing related to existing bioenergy subsidies. In 2008, an energy subsidy previously targeting renewable energy production in heat and power plants and energy efficiency was extended in terms of target groups and leverage mechanism to include the promotion of technology and piloting related to the production and use of new transport biofuels, initially with a minor subsidy but later constituting 10% of Finnish budget expenditure on climate (NaoF 2011). The increased subsidy links to an increase of the national transport biofuel target to 20% by 2020, taking into account the possibility of double-counting the contribution of biofuels developed through particular technological routes or feedstocks (Act 1420/2010). The aim of the higher distribution obligation was to create a 'secure and predictable domestic market for biofuels that encourages companies to carry out biofuel production investments', particularly in second generation technology utilising domestic raw materials. Policy impact assessment suggests that this will not require significant changes in fuel distribution systems, nor in the vehicle fleet (Government Bill 197/2010). The backing of the subsidy was based on landscape pressures, namely the cost of oil and climate change, as well as the goals to create technology export potential. The change in policy also coincided with a renewal of the forest industry regime towards energy products, following a decline in world paper markets (Kivimaa and Kautto 2010).

Discussion: CPI and socio-technical system linkages

We propose three conceptual types of climate policy innovation - original, diffusion-based and reframing-based – and present five exploratory hypotheses about how the types link to wider socio-technical change. The limited extent of 'original' policy innovation and the more frequent occurrence of 'diffused' and 'reframed' policy innovation that we observe in our illustrative cases can best be understood by exploring the dynamics of the socio-technical systems that the policies aim to influence. Supplementary cases would likely give rise to additional hypotheses.

Policy innovation intended to address path-dependent socio-technical regimes is most likely to result in socio-technical regime change in cases where it supports destabilisation of old systems, promotes new path creation and nurtures new systems. Conversely and contrarily, however, policy innovations are more likely to be taken into use when they promote path dependency and provide benefits to influential regime actors. Since system transformation takes time, transition-oriented policies need to be sustained over time: many studies have shown the importance of predictability and credibility of policies if they are to induce innovations and promote path creation (e.g. Kivimaa 2008). Indeed, this may hinder subsequent policy innovation. The difficulty in securing and sustaining political support for stringent climate policies (Lockwood 2013) implies the need for policy designs that allow either for increasingly tight targets or for policies that may be diffused to new target groups after they have been adopted (Levin *et al*. 2012). Given this conditionality, it is not surprising that we find original CPI to be rare: there are usually strong, regime-level interests in preserving the status quo. Moreover our transport policy cases suggest that diffused or reframed policy innovation is more likely to result from landscape pressure than from within the transport regime, thus supporting hypotheses H1 and H5.

In our case countries, national level transport-CPIs have generally not been designed and implemented with the intention of radical transformation of the transport system. There has, for example, not been national-level intention to promote climate change mitigation by significantly influencing demand for transport or the choice of transport mode (apart from public transport subsidies), lending further credibility to H1. While examples of city-level policy innovations, such as congestion charging, exist (Marsden *et al*. 2011), neither attention to sustainability nor climate change have had much influence on transport demand due to the dominance of engineering and neoclassical economics-based worldviews in transport-related policy discourses (Banister *et al*. 2011). Thus, many more transport-CPIs connect to sub-systems improving the efficiency of fuels and vehicles rather than to structural change (see Table 1). In the context of the whole socio-technical system, they reflect modular (sub-system) rather than architectural (whole system) innovation. This said, architectural innovation should be more observable when focusing on policy frameworks at the level of the nation state, though Kivimaa and Virkamäki (2014) show that this is not the case for Finnish transport policy. It would seem that constraints on the national level are also strong and that while niche innovations in motorised transport, recently supported by new policy instruments for the electrification of road transport, may well lead to some degree of system transformation in a low carbon direction, further reconfiguration in the direction of public transport and/or non-motorised transport is more difficult to achieve.

CPI often results from a successful policy measure in another policy domain or country, adopted in the context of a new socio-technical regime, or from reframing. In our cases of diffused and reframed policy innovations, particularly those linked to system level change, we can see multiple landscape pressures and the interaction of different interlinked regimes. Incumbent actors from interlinked regimes, here demonstrated by policies to support transport biofuels that have received push from the agricultural regime, industrial regimes and the energy regime, may coalesce to back up policy innovation (H1). While the resultant policy innovation in this case involves technology substitution, bearing out H2, the development of the biofuel regime may also lead mutually supportive processes. These in turn may lead to wider regime level change (H4), as exemplified in the changed business foci of some industry and agricultural regime actors (Kivimaa and Kautto 2010, Huttunen 2012), if not in transport then in the other regimes involved. The recent emergence of policy innovation addressing electric vehicles also gives further support to the hypothesis that CPIs supporting technical substitution options are favoured (H2). As Raven (2007) argues, the co-evolution of lightly connecting systems may – through path creation processes – be leading to symbiosis and the interaction of regimes, which is increasingly seen between transport, energy, agriculture and forestry.

Although the biofuels case involves multi-regime interaction, the vertical integration of extraction, refining and distribution found in the petroleum sector has facilitated modular, incremental change rather than new propulsion systems and drive trains. Existing institutions and networks have favoured policy for technological substitution (H3), rather than wider transport regime change (H4). Despite the interaction of multiple regimes being important to technological path creation and system transitions, evident also for policy innovation, this interaction has been little studied in the transitions literature (Raven 2007; Konrad *et al*. 2008). Indeed, the movement of biofuels from a niche to regime technology, supported by mandated policy diffusion and supplemented by reframing, is particularly interesting. Yet as both Ulmanen *et al*. (2009) and Upham *et al*. (2011) observe, from different perspectives, the degree of societal embeddedness of this technology is not guaranteed and the policy arena remains highly contested.

In general, policy reframing (H5) is likely to be less immediately disruptive to the established system than genuine policy innovation, while still responding to landscape pressure. Given the tendency of regime actors to seek to maintain their positions, we can posit that disruptive, innovative policies are less likely to diffuse than (reframed) policies that maintain any given status quo (this being problematic only in cases where existing policy instruments and reframed and diffused policy innovation fail to generate adequate outcomes). While several fuel tax and biofuel subsidy policies have after their implementation been reframed as climate policies in Sweden and the UK, the Finnish case of biofuel policies shows that a reframing of energy subsidies so as also to include a category for transport biofuels can initiate processes leading to new business development and more comprehensive policy mixes, supporting what was initially a minor policy change.

In general, we suggest that the dynamics of socio-technical change condition what is possible in policy terms. Socio-technical transitions concepts provide a useful way of thinking about the structural processes and influences involved, offering an explanation, for example, of why ‘original’ climate policy innovation is uncommon. Dominant interests may frustrate or facilitate policy change, the former being evident when policy solutions appear to exist but are opposed by those interests. For example, a recent policy ‘invention’ of kilometre-based taxation for vehicles based on different zones across Finland (MTC 2013) was heavily opposed. Similarly, we point to how socio-technological niches in the system are supported by small-scale policy support, typically research and innovation subsidies, the consequences of which may then play a significant role in justifying broader (‘regime’-level) policy in the short, medium and longer term. Biofuels are a classic case of this and also illustrate how the processes may be cross-national and long term, with, for example, Brazilian policy decisions regarding ethanol investment some three decades ago influencing contemporary European climate policy for transport.

From a socio-technical transitions perspective, it is socio-economic and material interconnections and interdependencies, together with shared ways of thinking and doing, that consolidate, maintain and reproduce systems of production and consumption. This is a key reason for the limited extent of ‘original’ policy innovation and the more frequent occurrence of policy diffusion and reframing. Policy reframing is less immediately disruptive to the established system than genuine policy innovation, and diffusion implements policy with known effects, or at least presumably known effects. Yet, reframing can shape and even enforce visions of the future direction of socio-technical systems, signs of which may be present in localised contexts, where niche-policy innovations are created and tested (e.g. Marsden *et al*. 2011, in the context of transport).

We have showed here that socio-technical transitions concepts can provide additional insights into the emergence of CPIs. What we have not examined are cases in which original policy innovation is able to take place because a dominant regime has been destabilised (for example, Iceland’s introduction of fisheries policies based on individual transferable quotas in the 1970s (Chu, 2008)). Another instance not examined is where transnational bodies are able to shape nationally dominant regimes through regulatory power (for example the EC in terms of directives or UN treaties), or when the impacts of a policy change on the dominant regime are underestimated or not foreseen (Hirschman, 1970). In the transport arena, none of these conditions yet apply on a broad scale.

We have not considered here cases of climate policy dismantlement or weakening; nor have we hypothesised the ways in which public opinion and changing norms and values interact with the different levels of the MLP to influence policy change or stasis. All constitute future research directions, as does work on understanding the inter-relationships of policy, politics and socio-technical change (Meadowcroft 2011), particularly in relation to the emergence and diffusion of CPIs. Similarly there is scope for work on how social policy and institutional innovations affect socio-technical change, particularly in contexts of derived demand, transport being one. In short, in proposing that structural accounts of socio-technical change can shed light on climate policy innovation processes, we aim to have opened up new ways of thinking and possibilities for various lines of work.

Conclusions

We have defined three types of climate policy innovation - original, diffusion-based and reframing-based. We then proposed five exploratory hypotheses that relate these to research on socio-technical transitions, particularly multi-level perspective and transition pathways, with illustration from climate-related transport policies in the UK, Finland and Sweden. This reveals that, to date, most CPI in this sector has focused on technological substitution and incremental change, rather than path-breaking innovations. Moreover it is clear that substitution and incremental options are typically supported by dominant regime actors and existing structures. We conclude that instituting policies with a wider systemic focus is likely to require the support of actors in multiple policy regimes. Overall we find that socio-technical transitions concepts help to provide additional insight into the emergence of particular types of CPI, particularly by directing attention to the differing dynamics and possibilities at the different levels of the MLP.

Although high-level framing of the MLP obscures the political processes involved, the processes involved in economic and policy change are of course profoundly political (cf. Meadowcroft 2011). It is at the regime level that incumbents of all types (institutional, political, corporate) are situated and, hence, it is at the regime level that substantial policy change can be expected to be most difficult and resisted by incumbents. If reframing-based CPI is more acceptable, this begs the question of whether and how reframing may serve as an entry point for future policy and regime change, particularly if supported by pressure at the landscape-level. Moreover, if original CPI is so difficult but reframing is possible, particularly when driven by landscape and niche level pressures, then a further question is whether reframing can function in a two-way process of mutual influence, perhaps by leading to higher level changes in social norms and values. In addition, although the changes in visions, norms and expectations necessary for voluntarily-reduced consumption and mobility are here considered as slow, landscape-level changes, shifts in societal norms do nonetheless take place, often assisted by campaigns that change perceptions of behaviour previously considered acceptable. As these connections between changes in norms and policy as part of wider socio-technical transitions have themselves been little theorised to date, this is another direction for new work.

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Table 1. Illustrative national policy instruments listed by EEA and IEA (2013) as climate policy instruments for land-based passenger transport in Finland, Sweden and the UK

Mode of CO_2 reduction **Type of policy innovation**	**Reducing transport demand**	**Influencing choice of transport mode**	**Reducing vehicle-specific emissions**	**Reducing fuel GHG-emissions**
Original CPI	None identified at national level	None identified at national level	None identified at national level	None identified at national level
Diffusion-based CPI			Car energy labels; *voluntary agreements* with car industry, and *with public transport services;* CO-based vehicle taxation (vehicle excise duty, annual vehicle tax, company car tax), government vehicle procurement rules; deployment subsidies for eco-cars and electric vehicles; mandatory/voluntary eco-driving.	*EU biofuels distribution obligation,* CO_2-emissions based motor fuel tax, *UK implementation of EU biofuel distribution obligation;* deployment subsidies for eco-cars.
Reframing-based CPI	*Annual fuel duty increases*	Public transport subsidies	*Speed limits*, automatic speed surveillance	*Swedish and Finnish subsidies for biofuels & implementation of EU distribution obligation*