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Conceptualising multi-regime interactions: The role of the agriculture sector in renewable energy transitions

Lee-Ann Sutherland[a,*], Sarah Peter[b], Lukas Zagata[c]

[a] Social, Economic and Geographical Sciences Group, James Hutton Institute, Craigiebuckler, Aberdeen, Scotland AB15 8QH, UK
[b] Institute for Rural Development Research at Johann Wolfgang Goethe University, Frankfurt/Main, Germany
[c] Faculty of Economics and Management, Czech University of Life Sciences, Prague, Czech Republic

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ABSTRACT

The agriculture sector plays an important role in renewable energy transitions, owing to its historical involvement in managing key resources, particularly land and biomass. We develop the multi-level perspective in relation to these emergent transition processes, conceptualising transitions towards renewable electricity production as examples of multi-regime interaction between national-level agriculture and electricity regimes. We focus particularly on the role of niche 'anchoring' into multiple regimes as the mechanism through which multi-regime interaction occurs, utilising case studies in Germany, the Czech Republic and the United Kingdom. Analysis suggests the birth of a new 'fiat' regime, oriented towards renewable electricity production. We suggest that fiat regimes, which are heavily dependent on policy supports, are often multifunctional in nature. In addition, we argue that agriculture's inherent connection to land demonstrates one of the specific characteristics of 'fiat regimes': fiat regimes are constructed largely in response to policy efforts to produce or protect public goods, such as natural resources, as opposed to 'market regimes' based on technological developments. Findings demonstrate support for the 'special case' of the agriculture sector in transition processes: high degrees of policy involvement led to 'windows of opportunity' created largely in response to national and international policy agendas, and the multiple functions of agriculture were reflected in competition between agriculture and electricity sectors over natural resource access. As renewable energy currently represents a secondary transition in the agriculture sector, we suggest that further attention needs to be paid to the impact of fiat regime policies on secondary transition processes.

1. Introduction

The European Union has set binding targets of producing at least 20% of its gross final energy consumed from renewable sources by 2020 (EREC, 2011), as part of their '20–20–20' strategy which also includes a 20% reduction in greenhouse gas emissions and 20% improvement in the EU's energy efficiency. In their National Renewable Energy Action Plans, Member States have identified their strategies for meeting these goals, which primarily focus on the energy sector: policy and regulatory frameworks, infrastructure and technology development, production price supports, and private sector investment. The plans are similar to international reports (e.g. the Stern Review of the Economics of Climate Change, 2006; Renewables 2014 Global Status Report; the IPCC Fourth Assessment Report), in that very little attention is given to role of the agriculture sector in energy production. The agriculture sector is described primarily as a problem in relation to emissions and energy consumption, and as a source of biomass. Neither are the trade-offs between food and energy production addressed to any degree. In this paper we draw attention to the role of the agriculture sector in renewable energy transition processes, further developing the conceptualisation of multi-regime interaction in the transition towards renewable electricity production.

Both the energy and agriculture sectors are high policy priorities at national and international levels, representing 'food security' and 'energy security', respectively, and are thus subject to considerable state intervention. EU renewable energy policy is typically traced back to the 1997 European Commission White Paper on Renewable Sources of Energy (EWEA, 2011), which set a goal of 12% contribution of renewable sources to the European Union's gross inland energy consumption by 2010 (EC, 1997, pp. 9). However, the European Commission had been supporting the development of renewable energy (e.g. technological research) for some decades previously. What is less recognised is that the European Union

* Corresponding author.
E-mail address: Lee-Ann.Sutherland@hutton.ac.uk (L.-A. Sutherland).

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has also supported farm business diversification into renewable energy production since the 1980s, through the Common Agricultural Policy. A shift in agricultural policy in 1984 saw a move away from direct production subsidies and towards a more diversified rural economy (EC, 1988). In Member States, measures aimed at assisting farmers to diversify their businesses included grants for renewable energy installations. Some of the technologies currently being utilised for renewable energy production were also historically developed to address agricultural issues, such as waste management (biogas) and milling grain and pumping water (wind).

The growing literature on renewable energy transitions similarly focuses on the energy sector, occasionally including the waste and transport sectors. Analyses frequently draw on socio-technical systems thinking, emphasizing the different pathways renewable energy technologies have taken in development (e.g. Garud and Karnøe, 2003; Raven, 2007; Raven and Geels, 2010; Verbong and Geels, 2007). The literature is disconnected from social research on production of renewable energy in the agriculture sector, which identifies farm-level motivations (Huttunen, 2012; Tranter et al., 2011; Sutherland and Holstead, 2014), preferred types (Bailey et al., 2008; Tate et al., 2012; Mbzibain et al., 2013), characteristics of adopters (Villamil et al., 2008; Tranter et al., 2011; Tate et al., 2012) and the impact of policy and price supports (Clancy et al., 2012; Mola-Yudego and Pelkonen, 2008; Wilkinson, 2011). Transition processes in agriculture are also addressed utilising socio-technical systems perspectives, but these papers tend to focus on alternative farming methods and marketing strategies, such as organic farming (Belz, 2004; Smith, 2006, 2007) and local food networks (Diaz et al., 2013; Darrot et al., 2015; Lošťák et al., 2015). However, system transition has become a popular topic in the agro-food literature in recent years, drawing on a variety of conceptual approaches that emphasise 'sustainability transitions' (e.g. Poppe et al., 2009; Barbier and Elzen, 2012), reflecting increasing concerns over the past three decades that conventional farming practices are not socially or environmentally sustainable, and that transition is thus required.

In this paper, we analyse the interactions between the agriculture and energy sectors to form the 'renewable electricity regime', by further developing the conceptualisation of multi-regime interaction within the multi-level perspective (MLP). The MLP has been developed through a branch of transition studies which provides a conceptual framework for analysing socio-technical system-level innovations. In the MLP, 'niches' are conceptualised as sources of radical innovation, which owing to favourable 'socio-technical landscape' pressures (broad societal, technological or ecological developments), exert influence on the dominant socio-technical regime. Socio-technical regimes are considered relatively stable, 'locked-in' to particular trajectories, tending to change incrementally. The MLP focuses on radical changes or transitions. In the case of renewable energy, landscape pressures in the form of political concern regarding climate change and greenhouse gas emissions, exerted considerable pressure on the energy sector to pursue alternative production practices. These new practices – together considered 'renewable technologies' – were largely developed outside of the energy regime. For example, much of the American wind energy research was undertaken by the aerospace industry (Gipe, 1995). Biogas technologies were developed primarily in order to address waste management problems (and manure treatment) in the agriculture sector (Bruns et al., 2009). However, these technologies were not simply co-opted into the energy sector, they remain anchored in physical terms in the resources traditionally associated with other sectors, particularly agriculture. Economically successful biogas production involves both slurry and energy crop production, inherently embedded in farming systems. While onshore wind energy production requires less direct farm involvement, turbines are often located on agricultural land. It is this inter-relationship between the agricultural and energy sectors that we explore here.

The overall purpose of the paper is to assess the role of the agriculture sector in renewable energy transitions. In doing so, our objectives are:

- To further develop the multi-level perspective in relation to multi-regime interaction.
- To assess the utility of the multi-level perspective for use in understanding transitions within the agriculture sector.
- To illustrate these theoretical concepts through empirical case studies of wind and biogas from three European countries.

The paper is structured as follows. In the next section we further develop our conceptualisation of multi-regime interactions, before describing the research methods and background to the cases. We then present our analysis of the transition processes in the three study countries, organised into periods of convergence (1987–1996), consolidation (1997–2006) and contestation (2007–2013). We conclude with a discussion of the implications of the 'special case' of the agriculture regime for the study of transitions, and argue that renewable electricity production can be conceptualised as a 'fiat' regime in its own right.

2. Conceptualising agri-renewables as multi-regime interaction

The multi-level perspective (MLP) has developed an extensive literature within innovation and technology studies over the past decade (for reviews see Genus and Coles, 2008; Markard and Truffer, 2008 Smith et al., 2010). The appeal of the MLP is in the conceptual link made between micro-level innovation processes and large-scale socio-technical systems (Smith et al., 2010). The definition of the socio-technical regime is typically traced back to Rip and Kemp (1998), who widened the regime concept to include 'rules' (i.e. institutions in various forms, in which technologies are embedded). Current definitions of 'regime' emphasise three elements: actors, systems (resources, material aspects) and rules/institutions (Geels, 2011), oriented around the fulfilment of a single societal function. Analyses utilising the MLP usually follow the development of a particular technology over time, describing its evolution from innovation or 'novelty' to mainstream use (Konrad et al., 2008). Most studies using the MLP focus on historical analyses (Genus and Coles, 2008), which make it possible to define the regime in relation to the technologies under consideration (e.g. Geels and Kemp, 2007; Geels and Schot, 2010); the scale of the regime is therefore variable, depending on the technology involved. Regime-level transitions can be as minor as the technological substitution of a new means of housing pigs in The Netherlands (Elzen et al., 2011) ranging up to the replacement of horses by automobiles in North America (Geels, 2005). As a result, it can be difficult to distinguish between radical transition and the incremental changes of established regimes, depending on the scale at which the analysis is undertaken (Darnhofer et al., 2015; Genus and Coles, 2008).

In this research, we identify two regimes: agriculture and electricity, while recognising that non-agricultural waste used in biogas production is typically considered part of a waste management regime (e.g. Raven, 2007). While a regime does not necessarily equate to a sector – Geels and Kemp (2007) are clear that a regime can exist at multiple levels – for these purposes, it is necessary to consider the whole agriculture production sector a regime, because renewable energy production occurs across farming types (i.e. on dairy, livestock and arable farms). The definition of regime at the level of the agriculture sector is somewhat problematic, as the sector is widely recognised as having multiple functions (e.g. food, fibre and energy production, as well as environmental and amenity resource preservation) (Hassink et al., 2012; Marsden and Sonnino, 2008). However, for these purposes, it is not possible to narrow in on a single function to define the agriculture regime at a smaller scale. The energy production sector could similarly be considered a regime in its entirety, although authors typically conceptualise multiple regimes within this sector. For example, Raven (2007) distinguishes the electricity regime within the energy sector, in his analysis of multi-regime interactions. Equally, other regimes could be included in the analysis: Huttunen et al. (2014) argue that biogas represents a 'cross-boundary innovation', between energy production, waste management, agriculture and transport regimes. However, it is beyond the scope of this paper to address the waste and transport regimes. Instead, we focus on the electricity regime, recognising that its scale is smaller than that of the agriculture regime.

In recent years there have been calls for further research into the interaction and development of regimes within the MLP construct (Geels, 2011; Raven and Verbong, 2007; Konrad et al., 2008). Early research, closely aligned with the strategic niche management literature, tended to focus on novelties and niches as sources of innovation and transition (e.g. Geels, 2004), whereas more recent conceptualisations emphasise that transition can also come about primarily from landscape pressures and interactions between regimes (Geels, 2011; Geels and Schot, 2010). Similarly, early MLP literature focused on single regime interactions, whereby one regime emerged from and replaced a preceding regime (typically through technological substitution), whereas it has been recognised more recently that multi-regime interaction is often important to transition processes, particularly those oriented towards sustainability (Raven, 2007). Geels (2011) argues that the growth of some sustainability-oriented niche innovations requires the interactions of two or more regimes, giving examples of biofuels and battery-electric vehicles. In this paper we assess the interactions of the agriculture and electricity regimes, in the development of renewable electricity regimes in three countries.

In the limited literature on multi-regime interaction, there is remarkable consistency in the application of the MLP concepts, which have branched and developed along a number of lines. In this paper we draw on three primary papers addressing multi-regime interaction: Raven (2007), Raven and Verbong (2007) and Konrad et al. (2008). All three papers identify similar actions of regimes: enabling and constraining production, consumption, and intermediary activities (e.g. transportation, distribution, with Konrad et al., 2008 emphasising governance), arguing that it is through these three types of actions that regimes interact. For example, regimes produce products for and consume the products of other regimes; farms within the agriculture regime consume electricity. Regimes may be subject to related governance structures or use the same intermediary systems (e.g. transport and telecommunications). Raven and Verbong (2007) identified four types of interactions between regimes: competition occurs when regimes start fulfilling similar functions; integration occurs when previously separated regimes overlap (e.g. through actor mergers); spillover occurs when practices from one regime become adopted in another; and symbiosis occurs when the two regimes reap mutual benefits from each other's existence. The literature on multi-regime interactions suggests that these interactions evolve over time. For example, Geels (2007) argues that the relationship between the radio and recording regimes evolved from competition to symbiosis.

In this paper we develop a conceptualisation of multi-regime interaction which is more nuanced than previous research. Earlier analyses of multi-regime interactions have been based largely on empirical observation of regime interactions, a weakness recognised by Raven and Verbong (2007) about their own typology. We note that in the existing multi-regime interaction literature, the role of niche development and landscape level pressures – central to the MLP conceptualisation – are missing. In order to conceptualise multi-regime interaction within the MLP, we suggest that socio-technical niches – typically considered to arise at the edge or outside of a regime – are more usefully constructed as located within a second or third regime (see Fig. 1). Numerous papers have pointed to the importance of hybridity to niche innovation (i.e. the collaboration of actors from different sectors) (e.g. Sutherland et al., 2015b; Geels, 2011; Elzen et al., 2012). Subsequent niches interact with multiple regimes, thus constituting a mechanism for multi-regime interaction. Additionally, as Geels (2011) points out, landscape pressures impact on multiple regimes, leading to increased interaction as the regimes alter their practices in response. To date, fairly limited attention has been given to the conceptualisation of landscape pressures within the MLP, although Geels and Schot (2010) make a case for the influence of different types of landscape pressure (degrees of pressure, intensity and duration of disruption etc.) leading to differential transition processes. The role of landscape pressures is widely conceptualised as leading to the destabilisation of existing regimes, creating windows of opportunity for niche development (Geels, 2004).

We utilise Elzen et al. (2012) conceptualisation of niche anchoring, in order to advance the conceptualisation of multi-regime interaction. In Elzen et al.'s development of the MLP, niches interact iteratively with regime structures, in three primary forms of anchoring. As the niche develops, it recruits actors from an existing regime (i.e. 'network anchoring'), which in turn shape the direction of niche development. 'Technological anchoring' refers to the further specification of the technology (i.e. development of the technology to meet regime needs). Wind technologies, for example, traditionally used to power local activities like pumping water, were further developed to produce electricity which could be exported into national grid systems, thus anchoring into the electricity regime. Elzen et al. (2012) also identify 'institutional anchoring', which reflects the changes in social values, rules and markets negotiated between niches and regimes. Within institutional anchoring, three sub-types of institutions are identified: cognitive or interpretative, relating to how people make sense of themselves and the world around them; normative, which is comprised of formal and informal rules (e.g. laws, regulations and policies) and economic, which concerns the rules and arrangements which govern market and economic activities. We suggest that many regime interactions occur as a result of changing landscape pressures (e.g. environment and climate change as well as the European political agendas relating to them, fluctuations in international commodity prices). Two or more regimes can be expected to invest in niches which address the new landscape pressure; similarly, niches can anchor into more than one regime.

In sum, we conceptualise multi-regime interaction as occurring both through direct interactions between the regimes, and through interactions between the landscape, regimes and relevant niches. These interactions occur between the rules, actors and networks, and technologies of the regimes and niches, and through the evolving functions of the niches and regimes: production, consumption and intermediaries/policy support. Opportunities for transition come about through landscape pressures, particularly policy measures that destabilise the existing regimes. We argue that niches are inherently flexible and anchor into multiple regimes, thus representing an important component of multi-regime interaction. We illustrate these processes through three European case studies.

3. Methods and (historical) background to the cases

In this paper, we assess the transition processes surrounding the development of renewable electricity regimes, and the role of national agriculture regimes in those transitions, through comparative case studies of the United Kingdom, Germany[1] (including former East and West Germany) and the Czech Republic (and former Czechoslovakia[2]). In identifying the case studies, the challenge of defining the regimes becomes evident. We have elected to define the agriculture and electricity regimes at national levels, owing to the national nature of electricity distribution through most of the time periods studied, and the importance of national level policies to electricity regime development and stability. Agricultural policy and markets, while heavily impacted upon by European level policies, are also differentially enacted by the different member states. We thus identify European policy as a landscape pressure, and discuss multi-regime interaction in terms of the national-level electricity and agriculture regimes.

Empirical findings are based on three comparative case studies. The research was undertaken utilising a combination of document review and interviews with key informants. Documents included regional, national and European-level policy documents and reports, newspaper articles, academic journal articles, and survey reports. Twenty eight in-depth interviews were also conducted which included regional and national government representatives, renewable technology suppliers, agricultural and renewable energy advisors and farmers who had adopted the respective technologies in the study countries. These data sources were assessed to identify the key events and factors in the time periods studied, and identify apparent trajectories of agriculture and renewable electricity transitions in the study countries. The gathered data were processed with the use of the qualitative data analysis techniques (e.g. thematic coding). It is important to note that findings presented are illustrative, oriented towards providing narratives of the emergent transition processes and interactions between the agriculture and electricity regimes, rather than a comprehensive assessment of the complex change processes in the national agriculture and electricity regimes during the periods studied.

To limit the scope of the research, we chose to focus on two technologies: biogas in Germany and the Czech Republic, and wind in the United Kingdom. This decision reflects the relative importance of the selected technologies within the agriculture sector and geographical differences between the three countries: to date there has been relatively limited uptake of biogas on farms in the UK, in part a reflection of the small percentage of land suited to production of maize and other energy crops/substrates[3]. In contrast, wind energy has been more commonly taken up on UK farms than in either Germany or the Czech Republic, owing to the availability of the wind resource, particularly in Scotland and Wales. Both technologies rely on farming resources (land and substrates); the comparison of the two technologies enables some assessment to be made of the importance of spatial location, and the differential dependence of the technologies on agricultural resources.

3.1. Background to the case studies

In the aftermath of the Second World War, national governments took a strong interest in the development of both their agriculture and electricity sectors. In all three study countries, the electricity production and distribution functions were nationalised, and remained so for several decades. Food production was nationalised as part of the collectivisation process in Czechoslovakia, with farms remaining privately held in Western Germany and the United Kingdom. Agriculture and energy policies (separately) were foundational to European integration, with treaties establishing common markets for steel (1951) and agricultural products (1962). All three countries pursued modernisation agendas for agriculture, encouraging mechanisation. Production intensified and increased; however, agriculture remained much more dispersed than electricity production (i.e. although there were fewer farms, numbers remained in the thousands, as opposed to a few dozen electricity plants in each country).

National-level energy and agriculture regimes in Germany and the UK thus have a history of strong landscape-level intervention from the EU, operating largely in parallel, but also symbiotically, with agriculture acting as a consumer of energy regime outputs. Both were also single function regimes, focused on production and distribution of specific commodities[4] until the 1980s. Overproduction in the agriculture sector in the 1980s across the EU (e.g. 'butter mountains', 'milk lakes') was a primary driver in the gradual reorientation of EU agricultural policies and subsidies. Substantial subsidies for farmers remained, but were justified on the basis of the role of agriculture in rural economic development, environmental maintenance and population retention. In Czechoslovakia the inefficiencies of the Soviet system were becoming apparent by the 1980s, requiring increasing state supports to meet production targets.

In terms of renewable energy development, biogas and wind were niches throughout this period. Biogas was experimented with in both East and West Germany in the early 1950s, with some 50–70 plants constructed, primarily for waste management purposes, but also to produce electricity and fertiliser for use on farms. The innovation lagged until the 1970s, when oil price shocks led to investment by Western governments in renewable energy technologies (Runci, 2005). This was the first point at which multiple technologies (e.g. wind, solar and biodiesel) were brought together as 'renewable technologies' (i.e. reinterpreted from their original, often locally oriented, purposes, and anchored into the electricity regime as renewable energy sources). The early experimenters with biogas were alternative (e.g. organic) farmers in West Germany, who addressed environmental concerns, whereas early agricultural experimenters in Czechoslovakia were collective farm staff (including engineers) dealing with the large waste management issues resulting from collectivisation. The first biogas plant was established in Czechoslovakia (in Trebon) in 1974, but investment remained at farm level until the 1990s. The UK government funded research and development of large-scale wind technologies in the 1970s and 1980s (Connor, 2003), but smaller-scale versions were simultaneously being introduced at farm-level for on-farm use (e.g. powering refrigeration units and electric fences). Agriculture regime actors were thus important to niche development of both technologies.

4. Multi-regime interactions

Our analysis of the multi-regime interactions in renewable electricity transition is divided into three periods, based on key events/turning points in the evolution of renewable electricity production: national energy policy shifts in the late 1980s; the 1997 EC energy paper from which stemmed national targets for renewable energy production; and the 2007 rise in commodity prices and the food/versus fuel debate. In each section we first draw attention to landscape-level pressures, particularly EU policies, before focus-

[1] Where not further specified, we refer to Germany as a whole, after reunification.

[2] In our description we refer to the Czechoslovakia for the time period until 1992, when Czechoslovakia was divided into two independent states. From 1993 we refer to the Czech Republic only.

[3] Although the digestion process typically relies on slurry, it is the addition of undigested substrates that enables the production of sufficient energy for the process to be economically viable.

[4] Arguably, under collectivisation in Czechoslovakia, collective farming served multiple functions of food production and local employment.

ing on transition processes between regimes and niches at national levels.

4.1. Convergence (1987–1996)

In the late 1980s, environmental considerations rose on the EU agenda. Increased international concerns about the environment, as expressed in the 1987 Brundtland report 'Our Common Future', impacted on both energy and agriculture policies. Until the 1990s, energy policy in the EU had been primarily economic, but now reoriented towards environmental regulations. The ongoing reforms to the Common Agricultural Policy (CAP) were reflected in a shift away from market to producer supports in the 1992 MacSharry reforms; price supports were reduced and direct aid payment to farmers increased, linked to a new series of agri-environmental measures, including the first EU legislation on organic farming. These coincided with the 1992 Rio Earth Summit, which launched the principle of sustainable development. At the same time, after a period of low oil prices in the mid-1980s, prices were rising, spiking in 1990 in response to Iraq's invasion of Kuwait. In Eastern Europe, communism collapsed in 1989, leading to the reunification of Germany and political instability in Czechoslovakia, which divided to become the Czech Republic and Slovakia in 1993.

Changing landscape pressures had the effect of destabilizing both the electricity and agriculture regimes at national levels. In the UK, this was primarily in the form of changes to production demands. The UK government introduced the non-fossil fuel obligation (NFFO), through the Electricity Act of 1989. This required electricity providers to purchase electricity from non-fossil fuel sources at fixed prices. At the same time, the UK was involved in a process of privatising its electricity production and distribution processes. The intent of the NFFO had been primarily to encourage private investment in nuclear facilities, but also encouraged investment in renewable energy production, such as wind. In terms of the agriculture regime, farms were increasingly being encouraged to diversify, in response to declining production subsidies from the 1992 MacSharry CAP reforms, and low commodity prices. The first commercial UK wind farm (i.e. one which sold electricity into the national grid system), was located in England: Peter Edwards installed 10 turbines on his farm in 1991. As a niche, wind energy production thus anchored institutionally (normative and economic anchoring in the form of state intervention in market demand) and technologically (scaling up to export electricity) into the electricity regime. Agricultural actors also engaged in renewable energy production (network anchoring), but wind energy remained peripheral for both agriculture and electricity suppliers in this period: of 302 wind projects awarded NFFO status in the 1990s, only 75 were ever constructed (Wong, 2005 in Pollitt, 2010). The agriculture and electricity regimes interacted symbiotically, but in response to different landscape pressures (agricultural diversification, demand for energy based on non-fossil fuel).

In Germany, reunification in 1990 brought with it a number of changes to regime structures. Environmentally hazardous quantities of manure on the former East German collectives sparked research and funding on biogas, and a state funding programme for producers of renewable materials ('Nawaro') was introduced (i.e. normative and economic institutional anchoring of the biogas niche into the agriculture regime). In 1991, the new Electricity Feed-in Law (*Stromeinspeisungsgesetz* – StromEinspG), introduced a minimum compensation for electricity from renewable sources fed into the grid (including biogas[5]) (normative and economic institutional anchoring into the electricity regime), marking a shift from biogas as a waste management issue to one for electricity production. Feed-in tariffs were accompanied by numerous legal adaptations (e.g. in the sectors of construction, spatial planning, emissions and water/waste). In contrast to the UK, the MacSharry reforms, although generally leading to diversification of farm incomes, had no apparent impact regarding the development of renewable energy. Instead, increases in the feed-in compensation (the 1994 StromEinspG amendment) in combination with the Federal Ministry for the Economy's '100 Million Programme' which provided investment funding for setting up facilities for renewable energy production were a major factor in the increase in biogas plants based on liquid manure (normative and economic institutional anchoring into the electricity and agriculture regimes). The spectrum of biogas actors expanded to include the waste industry, industrial biogas plant operators and energy suppliers (i.e. network anchoring into the electricity regime). By the mid-1990s, a range of conventional farmers were also entering the biogas sector (network anchoring into the agriculture regime). In the German case, the electricity and agriculture regimes interacted symbiotically, but primarily in response to state supports through the energy sector and pressure on the agriculture regime to address waste issues.

In Czechoslovakia, all other landscape-level pressures observed in Western Europe were overshadowed by the impact of the collapse of communism. In the agriculture regime, market liberalisation, privatisation, reduced state investment and political uncertainty led to massive production declines. The electricity regime remained state-controlled. In 1991, the Czechoslovakian government set limits on the use of brown coal (formerly its primary source of electricity production), pursuing nuclear energy as a clean energy source. The first Czech energy strategy in 1992, in response to brown field sites from brown coal, included some acknowledgement of agriculture and the importance of increasing energy crop yields, but no associated funding supports. In 2003, the Czech Republic continued to pursue nuclear energy, but set EU targets for renewable energy production as part of its accession agreement. At this stage, energy continued to be addressed by a trade ministry, with no connection to the agriculture ministry. The two regimes thus remained functionally separate, with limited evidence of niche anchoring in either regime.

We conceptualise this period as the conception of the renewable electricity regimes in Germany and the UK. In all three cases, this period was one of destabilisation of national agricultural production regimes, and an increasing impetus for environmental protection. In Germany and the UK, a symbiotic relationship was established between the energy and agriculture regimes, where niche technologies were developed (in part) to address agricultural issues, were reconceptualised as technologies that could address the new environmental agenda, and were further developed by actors and institutions in both regimes (see Fig. 1). This anchoring into the agriculture and electricity regimes in Germany and the UK was a key feature of this period. Changing policy supports for renewable energy production, from research and development and into price and market supports, and new grid connection policies, combined with technological advances, made production economically viable at large scales and created a 'window of opportunity' for network anchoring into the agriculture regime, enrolling farmers in the production of electricity. However in Czechoslovakia, the energy and agriculture regimes remained separate, and biogas remained a farm-level niche (see Fig. 2).

4.2. Consolidation (1997–2006)

The 1997 European Commission white paper 'Energy for the Future: Renewable Sources of Energy' is utilised here as a marker of the beginning of the second development phase, 'consolidation'. The white paper set out the ambitions of the EU in relation to

[5] Prior to this point, biogas plants had been used to ferment/process manure into enhanced fertilizer.

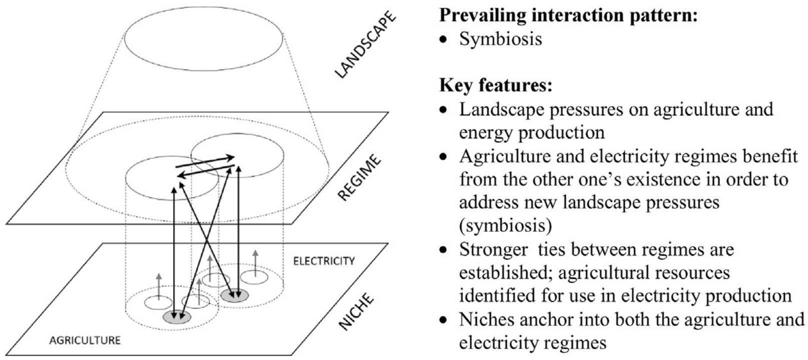

Fig. 1. Convergence period (1987–1996): Great Britain and Germany.gr1

climate protection, identifying the agriculture sector as 'a key sector for the European strategy of doubling the share of renewable energies in gross energy demand in the European Union by 2010' (pp. 21). Concrete targets for shares of electricity from renewable sources to be reached by 2010 were set by the Renewable Electricity Directive (Directive 2001/77/EC) in 2001: 10% for the UK and 12.5% for Germany. Energy targets for the Czech Republic were set by amendment of the Directive in 2006 at 8%. Notably, this directive was based on environmental regulations. At the same time, ongoing reforms of the Common Agricultural Policy (CAP) led to a decoupling of producer payments from production quantity, whereby most member states shifted from production-based to acreage-based payment schemes.

In the UK, ongoing destabilisation of the production-oriented agriculture regime was demonstrated by the replacement of the state Ministry of Agriculture and Fisheries with a newly formed Department for Environment, Food and Rural Affairs (DEFRA). The sector continued to be characterised by an increasingly vertically integrated system and rising farm sizes in order to achieve economies of scale. In this period, the UK government's supports for farm diversification into renewable energy production were dwarfed by the incentives offered through the electricity regime. In 2002, Renewable Obligation Certificates (ROCs) were introduced in Scotland, England and Wales, guaranteeing prices for renewable electricity production, normatively and economically institutionally anchoring renewable energy production into the electricity regime. This was followed by a proliferation of turbine developments across the UK, but most notably in Scotland and Wales, where the majority of the wind capacity is located. These turbines were typically owned by non-agricultural commercial companies (and operated on rented or purchased agricultural land), although there were pockets of farm-based developments, most notably in north-east Scotland (see Sutherland and Holstead, 2014). In 2003, the UK government implemented their first formal energy policy in 20 years ('Our Energy Future – Creating a Low Carbon Economy'), identifying objectives to both limit carbon dioxide emissions but also to increase the role of renewable technologies in economic development. The UK renewable electricity niche further anchored institutionally into the agriculture regime (e.g. economic institutional anchoring evidenced by the Co-operative Bank becoming active in providing loans for on-farm wind turbines) and developed networks specific to renewable energy production (e.g. the establishment of bodies such as the British Wind Energy Association, the Scottish Renewables Group and the Scottish Wind Farm Birds Work Group). Technologically, turbines continued to be developed by private companies (primarily outside of the UK), becoming larger and thus yielding higher energy output, running more quietly and reliably. In the UK, the agriculture and energy regimes thus continued to interact symbiotically to address a shared function of renewable energy production.

Bruns et al. (2009) identify three phases in German biogas development during this period. Following substantial state funding for biogas plant construction (normative and economic institutional anchoring), by 1998 ca. 400 biogas plants were installed, mostly based on liquid manure in smaller animal production enterprises. Network anchoring occurred between pioneering farmers, engineers, and businesses as up-take increased. Technological progress was mainly driven by producers of biogas plants, with only limited influence of the research sphere. In 1998, under the new red-green national government, climate protection was institutionalised in the Ministry of the Environment. A Renewable Energy Law (EEG) introduced in 2000, guaranteed long-term feed-in tariffs, ushering in what Bruns et al. (2009) term the second phase of Germany's biogas development. From 2000 to mid-2004 the number of biogas plants quadrupled, while the sector experienced increasing professionalization with 'turnkey' plants and services (set-up, monitoring, process steering) provided by expanding businesses (technological and economic institutional anchoring). The begin-

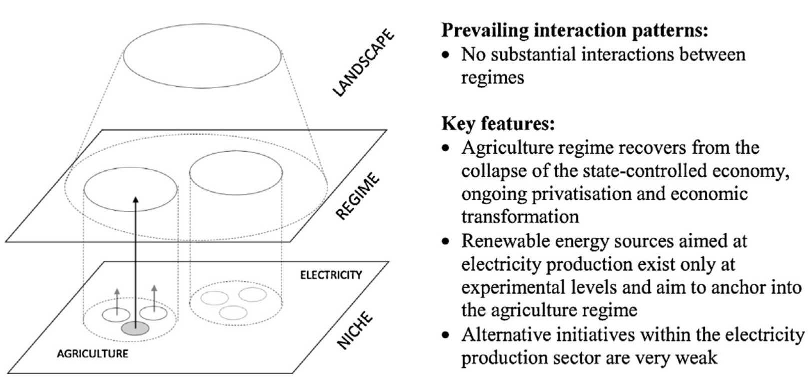

Fig. 2. Convergence period (1987–1996): Czech Republic.gr2

ning of the national 'Energy Turnaround' policy in 2002, prioritised energy and climate objectives rather than waste industry interests; in the same year, renewable energy policy was institutionalised in the Ministry of the Environment. The third 'boom' phase (Bruns et al., 2009) resulted from the 1st EEG amendment in 2004 (a response to the EU Renewable Electricity Directive 2001/77/EC, supporting electricity generation from renewable energies in the domestic electricity market). Biogas 'parks' of multiple 500 kW plants were established. In 2005, a climate protection programme was launched, with national policy putting renewable energies (and the 'Energy Turnaround') explicitly in the context of technology innovation for German economic development. An expansion of the feed-in compensation by a bonus for renewable materials ('Nawaro') – within the scope of the EEG's first amendment in 2004 – made energy crop cultivation (especially maize) highly attractive for farmers at a time when low agricultural prices rendered energy crops more profitable than food and feed production; energy crop cultivation rapidly expanded (normative and economic institutional anchoring into the agriculture regime). Arguably, the symbiosis of agriculture and energy regimes[6] led to the birth of a new renewable electricity regime; by 2006 there were 3300 biogas plants in Germany.

In the Czech Republic, this period was dominated by post-socialist transition. The preparation of the agrarian sector for membership in the EU was fairly complicated, in part because Czech agricultural policy was primarily focused on production and did not address the environmental and rural development aspects of the CAP. The negotiation period lasted from 1998 to 2002; the Czech Republic became a new member of the EU in 2004. Feed-in tariffs for renewable energy production were established in 2000 but large hydro plants were the primary recipients; other technological niches were not developed. By 2002 there were only six biogas plants in the Czech Republic, rising to 23 in 2005. In 2004 the new State Energy Conception of the Czech Republic was passed (MIT, 2004). However, although the document included sustainability ideals, the support for renewable energy production remained symbolic. The main emphasis remained on nuclear energy; the Temelin Nuclear Power Station had been opened in 2002. New investment opportunities for biogas were included in the new Rural Development Programme (RDP), under an agricultural diversification measure (normative and economic institutional anchoring into the agriculture regime). The number of installed plants grew from 36 in 2006 to 56 in 2007. The biogas niche thus continued to anchor primarily into the agriculture regime.

We argue that in this period, Germany saw the birth of a renewable electricity regime, with distinct sets of national policies oriented towards its support. The new regime derived in part from symbiotic interaction (resources, markets) and spill-over interaction (technology, know-how and institutions) between the electricity and agriculture regimes. The agriculture and electricity 'parent' regimes maintained their respective structures (see Fig. 3), although the new regime was dominated by energy sector policies and two streams of actors: actors involved in on-farm biogas, and large-scale industrial biogas actors. However, biogas production remained a farm-level niche in the Czech Republic, with modest normative and economic institutional anchoring into the agriculture regime largely in response to EU-level landscape pressures. In the UK, while solidly anchored into both the electricity and agriculture regimes, wind energy development clearly lagged behind German biogas development and was more dominated by the electricity regime.

[6] In combination with the up-take of other renewable energy technologies beyond biomass (like photovoltaics).

4.3. Contestation (2007–2013)

This period was initiated by the global food crisis in 2007. The agriculture regime in all three countries experienced rising input and commodity prices. The crisis deeply affected economic aspects of on-farm electricity production, challenging the position of the new renewable electricity regime and modifying interactions between the two parent regimes.

In the UK, the renewable energy sector was shaped by the Energy White Paper (2007) which outlined aims to decrease carbon dioxide emissions and secure affordable energy supplies, and provide a substitute for aging nuclear power stations. Social acceptance of turbine developments (generally high in Europe in the 1990s, Wüstenhagen et al., 2007) became an important issue in this period, evident in the UK by a rapid increase in the number of objections to new turbine planning applications (demonstrating weakening of cognitive institutional anchors). The government continued to provide the vast majority of its supports to large-scale developments, but also implemented 'Recommended Community Benefit Payments' and initiated programs to encourage community-led developments (e.g. the Local Energy Assessment Fund in England, and the Community and Renewable Energy Scheme in Scotland). In 2010, the UK introduced feed-in tariffs across the range of renewable technologies (including wind); these guaranteed electricity prices specifically for small to medium-scale renewable energy projects (normative and economic institutional anchoring). Rapid increases in the numbers of turbines followed, with new companies entering the market to supply smaller-scale turbines. However, rapid up-take of solar feed-in tariffs led to government reductions of the associated feed-in tariff payments, causing uncertainty for farmers applying for other forms of renewable energy production, including turbines. Government policies encouraging community engagement had the effect of further enabling large-scale wind developments by companies who were able to manage the growing transaction costs of turbine development: grid access became increasingly difficult as did accessing planning permission (i.e. competition between the electricity and renewable electricity regimes). Large corporations were therefore able to purchase or lease considerable quantities of agricultural land for turbine construction. By mid-2013 the installed capacity of the onshore wind power in the UK reached about 7500 MW (UKWED, 2014).

In Germany, prices of maize and wheat more than doubled between 2006 and 2008, initiating the food vs. fuel debate and questions regarding the best use of agricultural land. New biogas plant establishment declined, but by mid-2008 the sector again began to expand. The Integrated Energy and Climate Programme (2007) and the Gas Grid Access Regulation (2008), prioritised renewable energy access to the grid. The amendment of the EEG in 2009 led to another acceleration in the development of the biogas sector. Changes in the compensation system favoured a more effective use of manure and residual materials, and bonus payments for smaller plants with up to 500 kW were introduced (while funding for large 'biogas parks' was eliminated). New technological experiments with biogas technology, driven by both companies and farmers, emphasised economic efficiency (technological anchoring into the renewable electricity regime). Energy tourism, whereby tourists were encouraged to visit energy plants, started to develop (new niche development within the renewable electricity regime). In 2010, within the framework of the 'Energy Turnaround', the 'Energy Concept 2050' (Energiekonzept 2050) was enacted by the German federal government (with the overall objective of achieving an energy supply primarily from renewable sources by 2050), followed by the resolutions on the 'Energy Turnaround's' acceleration in 2011 (in response to the Fukushima nuclear catastrophe). Although, a study found that a large majority of the German population was in favour of an expansion of renewable energy in general

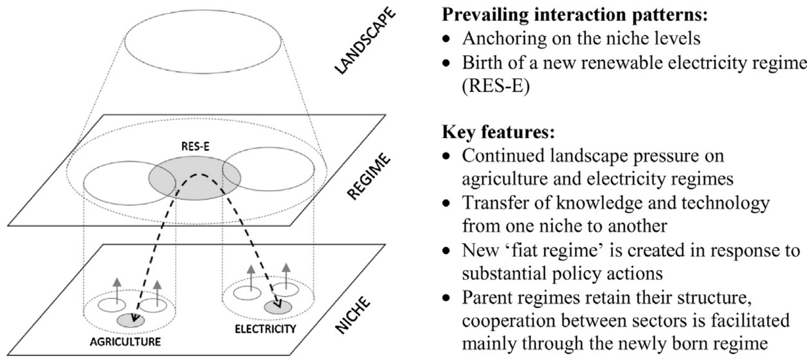

Fig. 3. Consolidation period (1997–2006): Great Britain and Germany.gr3
Note: The Czech process during this period was the same as in Fig. 2, with stronger anchoring into the agriculture regime.

in 2012, those individuals immediately impacted upon by development were less enthusiastic (BMU, 2013) (weakening of cognitive institutional anchoring in locations where the plants were constructed). Biogas – and associated energy crop cultivation, was identified as the least accepted source of renewable energy, owing to conflicts with food production, the spread of monocultures, as well as negative impacts on biodiversity (Ruppert-Winkel et al., 2013). As such, the renewable electricity regime continued to build formal institutional supports on multiple levels, but biogas in particular was increasingly contested.

In the Czech case the biogas sector continued to grow throughout this period (83 installations in 2008; 115 in 2009) (ERO, 2014), in response to the new RDP launched in 2007 (ongoing normative and economic institutional anchoring into the agriculture regime). Development of the biogas sector was not affected as much by the global food crisis as in Germany, but more so by radical and uncontrolled development of competing renewable technologies. From 2009 to 2010 the Czech Republic experienced exponential growth in photovoltaics, in response to feed-in tariffs. The immediate policy response was to reduce the tariffs and stop support provided for renewable energy installations through the RDP (i.e. removal of normative and economic institutional anchors into the electricity and agriculture regimes). Support was renewed again in 2010 and, similarly to Germany, put new emphasis on efficiency of the plants and use of waste heat. In 2012, the third amendment of the Renewable Energy Law was passed, which confirmed supports for producers of renewable electricity (normative and institutional anchoring into the electricity regime). Experiments were conducted at farm level focusing on alternative sources of biomass that could be obtained from less-favourable land (e.g. grass as a substrate) (new niche development). The potential for providing direct benefits from the instalment of the technology to local areas (e.g. cheaper energy or heat) were also explored. However, in 2012 the Czech government started preparations to cease financial support for renewable energy production. This decision was based on achievement of the EU renewable energy target of 13.5% and by critical public opinion of support for renewable energy production (weakening of cognitive institutional anchors), which had become a significant burden for public budget (ERO, 2012). Anchoring patterns preceding the birth of a new regime took place at a much faster pace than in the other two cases and were removed very quickly; it is thus debatable whether a new 'renewable electricity regime' was born, before biogas production reverted to being an agriculture regime niche.

The contestation period was characterised by declining social acceptance of renewable energy. In addition, the farmers producing electricity were also affected by increased opportunity costs (rising input costs and cereals prices), and heightened uncertainty in relation to subsidy payments. In conceptual terms, the global food crisis led to competition between electricity and agriculture regimes over key resources (particularly land use, but also for intermediary activities, such as access to the electricity grid) (see Fig. 4). At the same time, the renewable electricity regimes continued to develop through supportive policy measures, and technological advancement. In all three countries, new initiatives to increase local-level engagement were undertaken. The tenet that the public should benefit from renewable energy subsidies – heavily supported from state budgets – rose on the policy agenda. Policy was implemented to fulfil multiple functions through the investment in renewable electricity (e.g. preservation of local amenities, creation of jobs, reduced costs of local heating). The implications of these expectations of new 'fiat regimes', are explored in the next section.

5. Discussion

In this paper, we have developed the MLP in relation to multi-regime interaction, illustrating our conceptualisation with case studies of agriculture and electricity regime interactions, in the

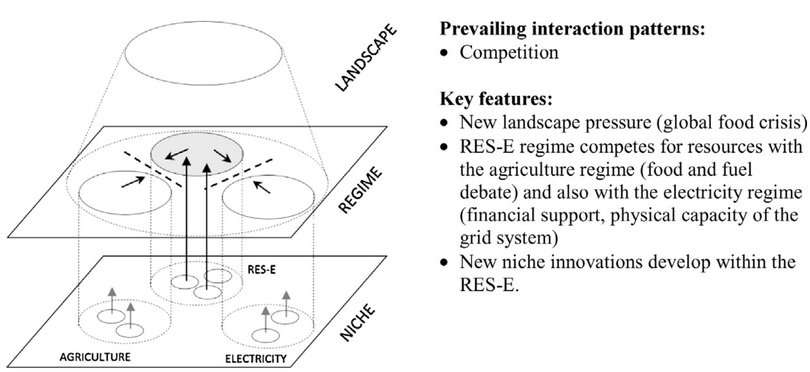

Fig. 4. Contestation period (2007–2013): Great Britain, Germany and the Czech Republic.gr4

development of national renewable electricity regimes. In this section, we discuss three key contributions of the paper: the definition and characteristics of 'fiat regimes', the role of anchoring in multi-regime interaction, and the role of landscape pressures in regime change.

5.1. Conceptualising the fiat regime

In this paper, we have identified the 'birth' of a fiat regime. In assessing multiple regime interactions, we built on the Raven and Verbong typology to include 'birth', particularly evident in the German case. Raven and Verbong (2007) are clear that their list of ideal types of interactions is not exhaustive, simply comprising those interactions observed in their empirical research. We define 'birth' as a situation when a new societal function arises of sufficient strength that a new regime is created to respond to it. Preconditions for the birth of a new regime are based on spill-over effects (transfer of rules and technology) between the two regimes. These two (or more) parent regimes retain their structures, but actors may be involved in multiple regimes.

We term the new renewable electricity regime a 'fiat regime', drawing on the Oxford Dictionaries (2015) definition of 'fiat' as "a formal authorisation or proposition; a decree". The targets set by the European Commission, implemented nationally, represent strong formal propositions institutionalised in national renewable energy production targets. In the cases of the renewable electricity regimes assessed here, the new regimes formed are characterised by new sets of rules and regulations specifically in support of renewable electricity production. In terms of function, the new renewable electricity regime involves different production techniques from those of either the electricity or agriculture regimes, but engaged actors from both, and distribution channels from the electricity regime. We thus argue that new fiat regimes were born, while recognising that the criteria for defining regimes are not absolute. As discussed in Section 2, the precise definition of a regime is somewhat subjective, largely dependent on the focus of the research. Van der Loo and Loorbach (2012) for example, identify the targeted Dutch policy programme for renewable energy transition as a niche within the energy regime. Our purpose in defining a fiat regime is to draw attention to the importance of policy in regime formation and the particular features which result when policy is a dominant landscape pressure.

The first of these features is that fiat regimes appear to be inherently multifunctional, as governments seek to meet multiple objectives in addition to the original purpose of the supports. In both Germany and the UK, national governments sought to develop renewable energy production as an economic development strategy, in addition to addressing climate change. The orientation of state supports can thus be expected to diverge over the course of development. In the Czech Republic, renewable energy supports were oriented towards achieving EU membership; once met, the normative and economic institutional anchors were dissolved. The Czech case in particular thus demonstrates the second feature of fiat regimes: that their stability appears to be strongly related to the depth of anchoring into the associated institutions. Institutional supports in the Czech Republic had considerably less time to anchor, and were much more peripheral to overall state objectives than in Germany and the UK. The lack of cognitive institutional anchors became apparently almost immediately after the initial normative and economic institutional anchoring into the electricity regime occurred, and was instrumental in the removal of those anchors. This raises the third feature of fiat regimes – the importance of cognitive institutional anchoring. In all three cases, perceived social acceptance issues coincided with alterations to the normative and economic institutional supports. As Van der Loo and Loorbach (2012) argue, energy transition is not possible without societal support. While markets are also impacted upon by social acceptance of the associated technologies, democratically elected governments respond to social acceptance in ways in which the market does not, making fiat regimes particularly reliant on (perceived) public opinion.

In line with this latter point, the long-term sustainability of fiat regimes is an inherent problem: fiat regimes are explicitly formed to support public goods, which would otherwise not garner sufficient market supports to develop. In all three cases, normative and economic institutional anchoring was combined, as governments intervened in markets to enable renewable electricity production. While the need to 'protect' niches from competing markets during development is well established within the MLP literature, for public goods, this need appears to be longer term. Although, the intention of national policy supports for renewable energy development in the UK and Germany was to enable the technologies to compete with conventional technologies in energy markets, this has not yet occurred. We have argued in more detail elsewhere (see Sutherland et al., 2015b) that there is a 'market bias' embedded within the MLP: technology-based transitions tend to follow market principles, which form the underlying assumptions of the MLP conceptualisation, whereas sustainability transitions do not necessarily lend themselves to market integration. Fiat regimes, formed in order to achieve or protect a public good, are implicitly constructed in order to address a market failure. They may therefore be dependent on state intervention for long term sustainability.

5.2. Conceptualising anchoring in multi-regime interactions

Through the case studies presented here, it is evident that niches developed in the agriculture sector successfully anchored into both the agriculture and electricity regimes, although these processes occurred differently in the three study countries. In the Czech Republic, biogas anchored most clearly into the agriculture regime, whereas in the UK wind anchored primarily into the electricity regime and in Germany, biogas anchored into both regimes. Findings are thus consistent with the literature suggesting that sustainability transitions involve multi-regime interaction (e.g. Raven, 2007; Geels, 2011) and that working across regime boundaries is an important source of innovation (Geels, 2011; Elzen et al., 2012). The cases demonstrate that innovation does not come from 'nowhere', but from actors who are integrated into different systems.

Findings also suggest that anchoring into multiple regimes can increase the stability of niche development. Particularly for sustainability transitions, where the new expectations of regimes are based on social and environmental criteria, multiple regimes can be expected to invest in similar innovative technologies in response to new landscape pressures. The combined investment power of the agriculture and electricity regimes studied here was a clear aid to transition processes; without these supports, the technologies are unlikely to have developed at the same pace. Anchoring into multiple regimes is also an important source of niche resilience. When state supports for renewable energy production were removed in the Czech case, biogas continued to be developed as a niche within the agriculture regime.

The different types of anchoring also appear to be important. Darrot et al. (2015) argue that all three types of anchoring need to occur in order for niches to successfully develop, but that they do not need to occur in a particular order. The absence of network anchoring in the Czech case underpinned the limited development of biogas. Technological anchoring was also weaker in the Czech case – whereas Germany had determined to cease nuclear energy production, inherent in the strong state focus on developing renewable energy production, the Czech Republic continued to rely on nuclear energy. The social acceptability of nuclear energy production within the Czech Republic was also reflected in institutional anchoring. In all three cases, the institutional anchoring initially involved a combination of normative and economic interventions (i.e. laws and regulations which acted to create or increase the markets for renewable energy), but was subsequently influenced by weak or absent cognitive institutional anchoring. This lack of cognitive institutional anchoring appears to have been key to alterations in the normative institutional supports, leading to their removal altogether in the Czech case. We suggest that the interplay between types of anchoring is an important topic for future research.

5.3. Conceptualising landscape pressures

Within MLP conceptualisations, landscape pressures are conceptualised primarily in terms of their role in regime destabilisation, opening up opportunities for niches to develop. In the cases presented here, multi-regime interaction occurred both in response to a shared landscape pressure (e.g. peak oil) but also in response to differing landscape pressures that led to symbiotic needs (e.g. diversification of income in agriculture and climate change policies). Geels and Schot (2010) in one of the few chapters specifically conceptualising landscape-level pressures, argue that the duration, magnitude and timing of landscape level pressures lead to different patterns of transition pathways. The case studies presented here support this contention: the Czech case in particular demonstrates that EU-level renewable energy targets instituted almost a decade later than in the German and UK cases led a much weaker renewable electricity regime, which quickly reverted to niche status.

The timing of landscape pressures also leads to differing interactions between regimes, and evolution of these interactions over time. In the cases presented here, the destabilisation of the agricultural production regime and shift towards multifunctionality occurred in Germany and the UK at the same time as landscape pressures on the electricity regimes opened ‘windows of opportunity’ for renewable technologies to develop. Commodity prices were low, creating an impetus for mainstream agriculture regime actors to engage with electricity production. Later; however, when commodity prices rose, the newly formed renewable electricity regimes competed with the agriculture regimes for access to land (as well as substrates) and with the electricity regime for grid access.

The limited conceptualisation of landscape pressures is a weakness of the MLP literature, particularly in relation to sustainability transitions. The geo-physical landscape in particular is under-conceptualised, impacting in the cases presented here on up-take of specific technologies. Wind was more commonly adopted in the UK owing in part to the availability of the wind resource; land capability to produce maize underpinned the establishment of biogas production in Germany and the Czech Republic. The need to integrate geographical concepts in order address the lack of attention to space within MLP conceptualisations has been addressed elsewhere (e.g. Coenen et al., 2012), and is beyond the scope of this paper. Here we comment instead on the role of land as a public good within the MLP. Natural resources such as land are notably missing from the MLP construct – land is not specifically conceptualised as a landscape pressure, or as inherently part of a specified regime or niche. We suggest that this absence reflects the MLP’s focus on technology, which is implicitly conceptualised as a spatial (e.g. automobiles and electronics can be produced almost anywhere). However, in seeking to address sustainability transitions, the omission of natural resources is a clear weakness of the MLP approach. We suggest that the lack of attention to natural resources reflects the market bias within the MLP construct – the MLP privileges market transactions without identifying a mechanism for assessing ‘who loses’, in environmental or social terms. This is an important area for conceptual development.

5.4. Limitations

In this paper, we have deliberately focused on two technologies that were of particular importance to the farming sector. Clearly, other renewable technologies, particularly photovoltaics, have also been taken up on farms – and elsewhere – and would be useful topics of future research into multi-regime interaction. Focusing on the two technologies here has been necessary to the purpose of the paper but should be considered in light of the essential role of non-agricultural (regime) actors. In drawing attention to the agriculture sector, we highlight the importance and impact of a secondary regime within transition processes.

In assessing multi-regime interaction across three case countries, the analysis has been necessarily brief. Although, we believe we have provided convincing evidence of the utility of the concept of anchoring to conceptualise multi-regime interactions, it is clear that further assessment and elaboration of the processes involved would be beneficial. Application of the MLP concepts empirically also demonstrated the range of factors involved, and the challenge of applying idealised conceptual terms to empirical research. For further exposition of the challenges of applying the MLP in empirical research, see Karanikolas et al. (2015). Further assessment of the transition processes presented here at regional level can be found in Sutherland et al. (2015a).

6. Conclusion

A primary aim of the paper was to assess the utility of the MLP for understanding transitions in the agriculture regime. Marsden (2013) argues that the agriculture sector represents a special case in terms of utilising the MLP, owing to the dependence of agriculture on land, state supports, and multiple functions. We find considerable promise in the MLP, particularly in relation to multi-regime interaction, owing to the multifunctional nature of the agriculture sector. In the analysis, the role of policy supports to renewable electricity transitions, and indeed farming transitions, have become clear. In turn, utilising the MLP to assess change in agriculture brings to light underlying assumptions regarding the nature of transition processes, such as the role of land and natural resources in sustainability transitions. The substantive policy intervention into the agriculture sector has also led us to identify distinctive characteristics of ‘fiat regimes’, suggesting that market-based assumptions underpin much of the MLP literature. The considerable differences between ‘fiat regimes’ and ‘market regimes’, particularly how they relate to sustainability transitions, are important topics for future research.

By locating the niches in the agriculture regime, as opposed to simply ‘outside’ of the electricity regime, it is possible to consider the effects of renewable energy transitions on the agriculture regime. Lawhon and Murphy (2011) point out the importance of recognising that changes in one regime can affect others through unforeseen consequences. The transitions presented here were secondary within the agriculture regimes of all three countries, which have continued to focus on agricultural commodity production[7]. However, farm-level innovators were important for the development of biogas technologies in Germany and the Czech Republic, and a farmer was the first to install a commercial wind farm in the UK. Supports through the national RDPs were important for biogas development in the Czech Republic, and early farm-level up-take of wind turbines in the UK. Farmers have accessed substantial financial supports through electricity production grants and subsidies, and currently compete with electricity production companies for

[7] There is considerable academic debate over the extent to which multifunctional transitions have actually occurred in the agriculture sector (Gorton et al., 2008).

access to land and grid connections. As such, we suggest that more attention needs to be paid to multi-regime interactions and the secondary impacts of renewable energy policies on sustainability transitions in other sectors.

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