

Policy Instruments for the Transformation to a Low-Carbon Energy System in the UK – Working Paper

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Keywords: Energy Economics, Energy Policy

Abstract

To produce extensive decarbonisation of the economy, the European energy system (and by extension those of its Member States), require transformational changes over the coming decades. Public policy, an essential driver, must be implemented across three policy pillars of ‘standards and engagement’, ‘markets and pricing’ and ‘strategic investment’, to address the three ‘domains of change’ of ‘satisficing’, ‘optimising’ and ‘transforming’. In doing so, the policy mix must be as effective, cost-efficient and feasible as possible, although trade-offs between each of these aspects is unavoidable. By dissecting the UK’s climate policy landscape along the lines of policy pillars and sectoral focus, some general conclusions may be drawn. Whilst the UK has a plethora of instruments spanning each of the three pillars of policy with primary focus across the five key sectors of power generation, industry, buildings, transport and agriculture, most instruments for the building sector, for example, fall under standards and engagement, whilst strategic investment is focussed on the power and transport sectors. Additionally, it appears that the perceived preference in the UK for market-based solutions, minimal governmental intervention and ‘picking winners’ does not reflect the existing climate policy landscape. Several potential options exist to improve the existing UK policy mix. Examples include a revised and expanded Climate Change Levy, the removal of reduced rate VAT on domestic energy, a requirement for Energy Management Systems and mandatory GHG reporting for large companies, and an expanded role for the Green Investment Bank. Such developments may significantly increase the rate of decarbonisation of the UK’s energy system, have progressive impacts if delivered with appropriate compensatory mechanisms and reduce administrative burden by removing now-redundant parallel instruments. Other objectives, such as the reduction of fuel poverty and increasing revenue from environmental taxes, may also be achieved in tandem.

Introduction

To retain a reasonable chance of avoiding significant climate change and the consequences this may hold, the global energy system must decarbonise very substantially by 2050. As with other regions, this implies a significant transformation of both energy supply and demand sectors in the EU and constituent Member States. Whilst there are numerous combinations of developments possible within and between sectors that could achieve this goal on aggregate, all three ‘domains of change’ of ‘satisficing’, ‘optimising’ and ‘transforming’ must be considered to deliver ‘smarter choices’, ‘cleaner products and processes’, and low-carbon ‘innovation and infrastructure’ (Grubb, 2014).

Figure 1 - The Three 'Pillars of Policy' (Source: Grubb, 2014)

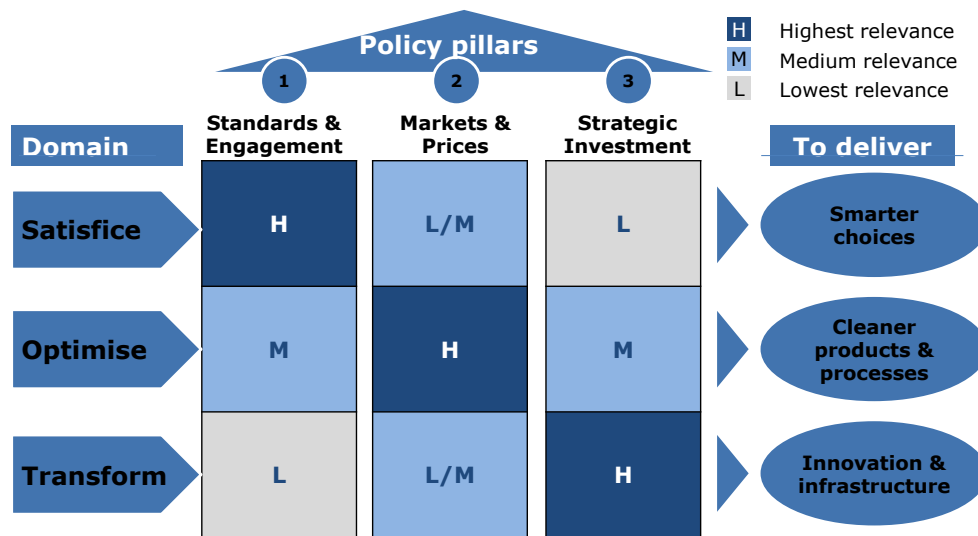


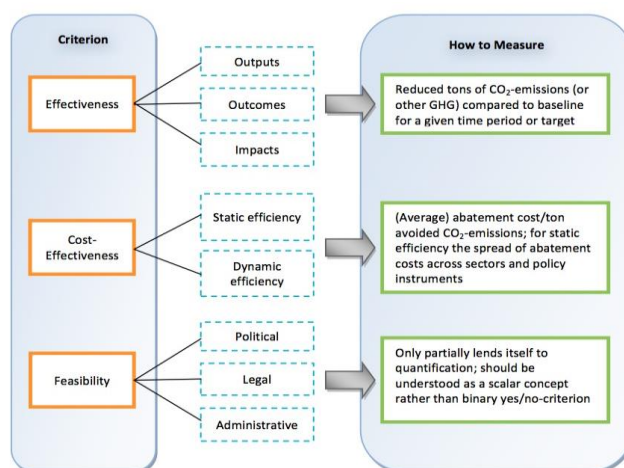
Figure 1 illustrates how these domains of change and outcomes relate to each other, and the principal 'pillars of policy' that must be employed as a catalyst. Each of the three domains reflects three distinct areas of economic decision-making and development. The first, 'satisficing', describes the tendency of individuals and organisations to base decisions on habit, assumptions and 'rules of thumb'. The first pillar of policy, 'standards and engagement', which includes policy instruments such as technology, emission and energy intensity standards and informational instruments, deals with these issues to produce 'smarter choices'. The second domain, 'optimising', describes the 'rational' approach of actors making 'optimal' choices based on economic factors. This reflects traditional assumptions around market behaviour and corresponding theories of neoclassical and welfare economics. The second pillar of policy, 'markets and pricing', which includes carbon pricing, employs this framework to deliver 'cleaner products and processes'. The final domain, 'transforming', encapsulates the ways in which complex systems develop over time under the influence of strategic choices made by large entities, particularly governments, multinational corporations and institutional investors. The insights of evolutionary and institutional economics may be employed in the third pillar of policy, 'strategic investment', to deliver 'innovation and infrastructure' under this domain (Grubb, 2014).

Each of the three domains and policy pillars, whilst presented as conceptually distinct, interact through numerous channels. As Figure 1 illustrates, each of the pillars of policy have at least some influence on all three domains. For example, instruments under markets and pricing, whilst principally impacting 'rational' economic decision-making under the 'optimising' domain, also influence the 'satisficing' domain (although limited by aspects such as information asymmetry and principal-agent problems, for example), and the 'transforming' domain (although limited by long-term uncertainty and consideration of non-price factors, for example). All three domains, and by extension all three pillars of policy, of largely equal importance in producing a low-carbon global energy system (Grubb, 2014).

Whilst mindful of the three policy pillars, the combination of policy instruments employed to produce short and long-term energy system decarbonisation should seek to be 'optimal', in

that it should be effective, cost-efficient (statically and dynamically), but also politically, legally and administratively feasible. Figure 2 illustrates this concept of optimality, as developed by the EU FP7 project CECILIA2050¹.

Figure 2 - Concept of 'Optimality' Developed by CECILIA2050 (Source: CECILIA2050, 2013)



In this paper we illustrate that by framing the UK climate policy mix in terms of the three pillars of policy, and allowing identification of the strengths and weaknesses of the instrument mix within these pillars, suggestions for improvement may be proposed that simultaneously improve the effectiveness, cost-efficiency and feasibility of the climate policy instrument mix in the UK. We first present the results of scenario modelling for a low-carbon energy system in Europe by 2050 using a newly-developed energy system model, the European TIMES Model (ETM-UCL). We then briefly discuss the existing EU climate policy landscape and its optimality, before investigating the UK policy landscape in terms of distribution between the three 'pillars of policy' and the five key sectors of power generation, industry, buildings, transport and agriculture. Based on this, we then highlight a selection of short and medium-term options for improvement to the UK climate policy mix, before demonstrating how this may advance the each of the three aspects of optimality. This paper focuses on energy system CO₂ emissions only, and policies to mitigate them.

Low-Carbon Pathways for the EU's Energy System – Results from ETM-UCL

The European TIMES Model (ETM-UCL)² is a dynamic partial equilibrium energy system model with an inter-temporal objective function to minimise total discounted system costs, based on the TIMES model generator. It is a technology-rich, bottom-up model with perfect foresight and covers energy flows across supply-side and demand-side sectors. The model comprises a total of thirty-one countries (EU28 plus Norway, Iceland and Switzerland), grouped into eleven 'regions', as presented in Table 1, along with a 'global' region.

¹ The project 'Choosing Efficient Combinations of Policy Instruments for Low-Carbon development and Innovation to Achieve Europe's 2050 climate targets (CECILIA2050) is a 3-year FP7 Project under the European Union's 7th Framework Programme for Research (Grant Number: 308680). www.cecilia2050.eu

² Refer to the following for more information Solano, B. and Pye, S. (2014) *European TIMES Model (ETM-UCL)*, Available at: www.ucl.ac.uk/energy-models/models/etm-ucl

Table 1 - ETM-UCL Regions

Region Code	Region Name	Countries Within Region
BNL	Benelux	Belgium, Netherlands and Luxembourg
SWZ	Switzerland	Switzerland
DEU	Germany	Germany
FRA	France	France
IAM	Italy, Austria, Malta	Italy, Austria and Malta
IBE	Iberia	Spain and Portugal
NOI	Norway and Iceland	Norway and Iceland
SDF	Sweden, Denmark, Finland	Sweden, Denmark and Finland
UKI	United Kingdom and Ireland	UK and Ireland
EEN	Eastern Europe – North	Estonia, Lithuania, Latvia, Czech Republic, Slovakia and Poland
EES	Eastern Europe - South	Slovenia, Hungary, Romania, Bulgaria, Greece, Cyprus and Croatia

Each region is modelled with supply, power generation and demand side sectors, and are linked through trade in crude oil, hard coal, pipeline gas, LNG, petroleum products, biomass and electricity. The ‘global’ region however is not characterised in the same way as the European regions, and may be considered simply as a ‘basket of resources’ from which other regions may import above products (except electricity)³. The model is calibrated to its base year of 2010, with energy service demand projected into the future using the exogenously calculated drivers of GDP, population, household numbers and sectoral output (linked to GDP), for each region.

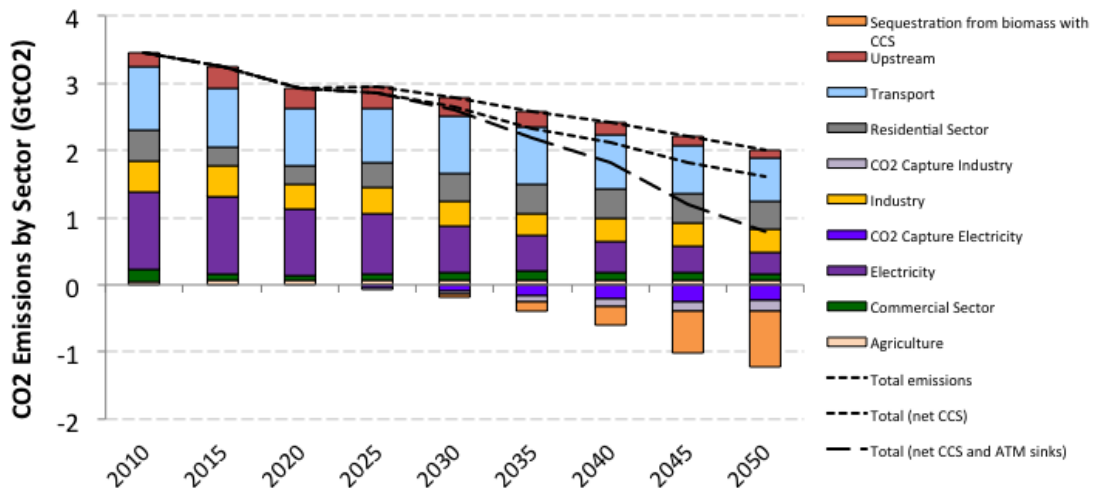
As part of the CECILIA2050 project three scenarios were applied to the ETM-UCL, a ‘Reference’ scenario in which CO₂ emissions are not constrained to 2050, a ‘Fragmented Policy’ scenario in which CO₂ emissions are constrained to 60% below 1990 levels by 2050, and ‘Policy Success’ scenario, in which CO₂ emissions are constrained to 80% below 1990 levels by 2050. The 2020 Climate and Energy Package targets for 2020 for CO₂ emissions and renewables are also imposed in each scenario. Whilst the 2050 CO₂ constraints apply to the EU as a whole, with each region contributing on a cost-optimal basis, the ‘UK and Ireland’ region has an additional constraint to reach an 80% reduction in CO₂ emissions unilaterally, commensurate with the requirements of the 2008 Climate Change Act⁴. Figure 3 illustrates the sectoral contribution to CO₂ reduction over time under the Policy Success scenario, at the EU level.⁵

³ Exports to the global region are not enabled in the model, due to the import dependence of the EU.

⁴ Although the Act applies to the UK only, as the UK accounted for nearly 93% of CO₂ emissions in this region in 2010 (European Environment Agency, 2014), such a constraint on the full UK & Ireland region is reasonable.

⁵ For more information on the scenarios, results and limitations of this study please refer to Solano & Drummond (2014)

Figure 3 – CO₂ Emissions by Sector- 'Policy Success' Scenario (EU-Wide)



It is clear from Figure 3 that the majority of CO₂ reductions over time are achieved in the power sector. This is produced through an increase in the use of renewables (from 18% to 45% of total power generation between 2010 and 2050), including wind, solar, hydropower and tidal power, but particularly via the use of biomass equipped with CCS, which produces negative emissions. The use of nuclear power remains roughly constant⁶. The use of coal becomes negligible, whilst natural gas reduces in prominence to 17% of total generation (from 27% in 2010), half of which is equipped with CCS. CO₂ intensity of power generation decreases from 348gCO₂/KWh in 2010 to negative at -190gCO₂/KWh in 2050 – a product of significant deployment of biomass CCS. CCS is also employed to produce the majority of the 60% CO₂ reduction achieved in the industry sector. Whilst CO₂ emissions from the commercial sector approximately halve, residential emissions reduce by around 10%. This is due to the exclusion of options for increasing building envelope efficiency (such as insulation), and demand elasticity, both key limitations to these results. However, a relatively marginal reduction is still achieved despite increasing energy service demand (a product of increasing population and household numbers), driven by increasing product efficiency and a relatively small proportional increase in the use electricity, heat pumps and natural gas, at the expense of more CO₂-intensive fossil fuels for heating. Road transport emissions decrease by around a third, driven by a shift from gasoline to diesel and biofuels in cars, from diesel to plug-in hybrid electric LGVs, and from diesel to biofuel and hydrogen-fuelled HGVs, along with vehicle efficiency improvements. A more substantial decarbonisation in road transport is likely prevented by relatively high investment costs (Solano & Drummond, 2014).

⁶ As the use of nuclear power is often a political rather than an economic choice, to ensure the role of nuclear was not over-represented, a maximum constraint was applied in that nuclear capacity cannot exceed 2010 levels across the assessment horizon – meaning capacity may only be replaced once existing plants close. The construction of new nuclear power was also prevented in Germany, to reflect existing policy.

Figure 4 - CO₂ Emissions by Region - 'Policy Success' Scenario (EU-Wide)

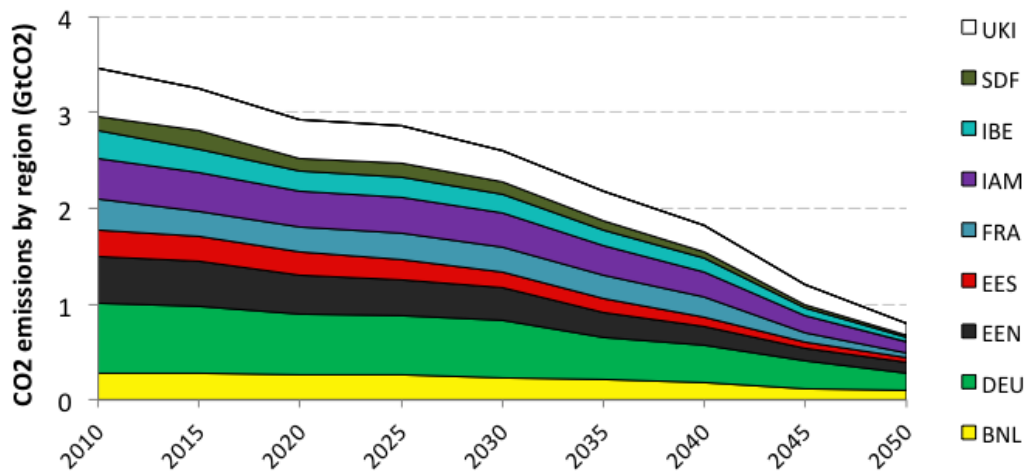
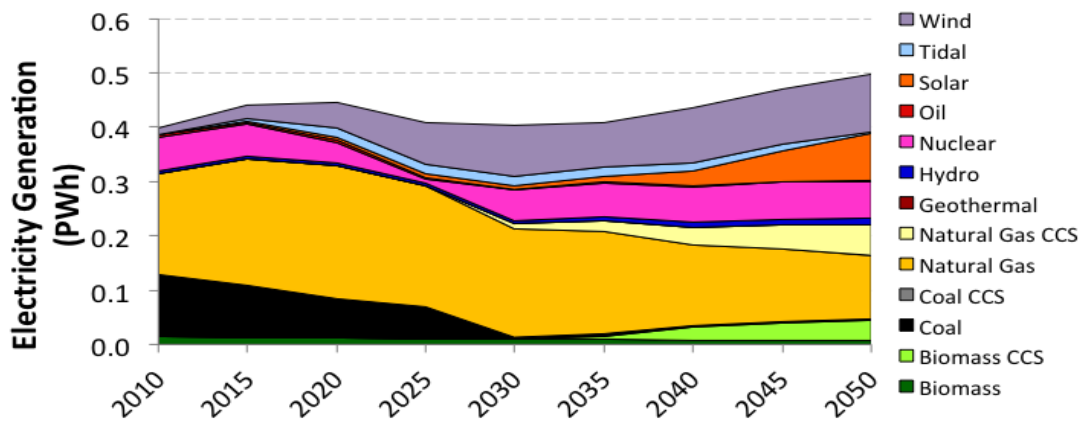


Figure 4 illustrates the regional contribution to CO₂ abatement in the EU between 2010 and 2050. Proportional contributions across all regions are relatively constant with around 80% reductions, although the range extends from a 67% reduction in the Benelux region to 90% in Eastern Europe – South. The manner through which these reductions are achieved varies between regions, particularly in terms of the power generation mix. Figure 5 illustrates the development of the power sector in the UK & Ireland region (hereafter simply 'UK').

Figure 5 - Power Sector Development - 'Policy Success' Scenario (UK-Only)



Developments in power generation in the UK are generally reflective of projected developments in the EU as an aggregate. Renewables increase from 8% to 51% of total generation between 2010 and 2050, including the introduction of biomass CCS. Coal diminishes to negligible use by around 2030, whilst natural gas retains a significant share, decreasing from 46% to 35% of total generation – around a third of which is equipped with CCS. Nuclear also remains largely constant in its share of generation, aside from a 'pinch-point' experienced around 2025 – the result of projected closures of existing plants and the lead time for new installations to come online. CO₂ intensity also decreases to negative, from 414gCO₂/KWh in 2010 to -205gCO₂/KWh in 2050.

European Climate Policy Mix Optimality

There are numerous EU-level policy instruments that impact CO₂ emissions across Member States. Many have explicit direct or indirect abatement primary or secondary objectives (such as the EU ETS (2009/29/EC), Renewable Energy Directive (2009/28/EC), Energy Performance of Buildings Directive (2010/31/EU), etc.), whilst others have a demonstrable impact but have no abatement-related objectives, such as the Nitrates Directive (91/676/EEC) and the Common Agricultural Policy in the agriculture sector (Kuik & Kalfagianni, 2013). Therefore, defining the boundaries of the EU-level climate policy mix is a difficult task. However, some conclusions on its optimality may be drawn from the CECILIA2050 Project:

Effectiveness – Meyer & Meyer (2013) calculate that for 2008, the combined presence of the EU ETS, renewable electricity (RES-E) support mechanisms and environmental tax reforms in eight Member States reduced EU CO₂ emissions by 12-13% below the counterfactual. This value is likely to increase relatively substantially with the inclusion of the impact other instruments, although instrument design concessions to retain feasibility along with relatively light co-ordination between instruments is likely to have reduced their aggregate effect below their potential. Although, an oft-cited negative interaction between the EU ETS and renewable electricity support mechanisms under the Renewable Energy Directive, in which the success of the latter depresses the price under the former (Frondel *et al*, 2010), is likely to be an overemphasised phenomenon. The abatement expected from the increasing penetration of RES-E was considered in the EU ETS cap-setting exercises, (European Commission, 2008). As such, only overachievement of expected deployment would induce this effect. As fifteen Member States failed to meet their indicative targets for 2010 laid down by the Renewable Electricity Directive (2001/77/EC) (European Commission, 2013), it is unlikely that this effect has yet occurred (Agnolucci & Drummond, 2014). However, other policy and non-policy factors, particularly the effect of financial crisis, are also likely to be significant drivers of abatement.

Cost-Efficiency – Whilst the EU ETS provides a single carbon price to around 50% of European CO₂ emissions, there are significant differences in marginal abatement costs and implicit carbon prices imposed by other instruments in different sectors and Member States, and some that overlap with the EU ETS (such as RES-E support mechanisms), producing static inefficiency. A principal example is the Energy Taxation Directive (ETD) (2003/96/EC), which imposes only minimum rates on energy products used for non-electricity generating purposes, including gasoline and diesel for road transport, leading to a significant range in fuel prices between Member States (Maca *et al*, 2013). Whilst the literature is in consensus that the EU ETS has produced very little innovation (Agnolucci & Drummond, 2014), there is also evidence that instruments such as RES-E support mechanisms, CO₂ intensity standards for passenger cars and the Ecodesign Directive have produced technical developments, reflecting a mixed dynamic incentive from the policy mix as a whole (Drummond, 2013). Meyer & Meyer (2013) also conclude that the combination of the EU ETS, RES-E support

mechanism and taxation reform in eight Member States have not reduced GDP or employment, and likely had a marginal net positive impact. There is also very little evidence that carbon leakage amongst Energy Intensive, Trade Exposed (EITE) industries has occurred (Branger & Quirion, 2013; Kuik *et al*, 2013), although negative distributional effects have likely arisen, particularly via the pass-through opportunity costs of grandfathered EU ETS permits in both the power and industry sectors (producing windfall profits), and the disproportional burden placed on residential energy consumers from RES-E support mechanisms (Agnolucci & Drummond, 2014).

Feasibility – By virtue of its existence the European climate policy mix is feasible, although many instruments faced, and continue to face, issues of administrative implementation, unintended side effects, flexibility, legal compatibility and political and public acceptability (Drummond, 2014). A key example of historic issues is that of the introduction of the EU ETS, which initially experienced explicit opposition from the European Commission in favour of a carbon tax. However, several factors converged to produce an ‘extreme about-face’ that occurred ‘virtually overnight’ (Hardy, 2007), that led to support and eventual adoption of the EU ETS. The initial carbon tax proposal eventually became the ETD, the result of heavy compromise that produced low minimum rates and numerous derogations (Drummond, 2014). A number of the provisions in the Renewable Energy Directive have not yet been fully implemented in a number of Member States, particularly those related to administrative barriers (European Commission, 2013). Aspects of implementation of both the EU ETS and RED have faced legal challenges in various Member States (Drummond, 2014).

Trade-offs between the three aspects of the extended definition of optimality illustrated in Figure 2 are ever present, and inherent to any policy mix. As such, whilst the European climate policy mix is sub-optimal, it must be recognised that the concept of optimality illustrated in Figure 2 is simply a theoretical point of reference. Nonetheless, lessons may be learned from past experiences to increase effectiveness, cost-efficiency and feasibility in tandem. However, an issue arises in that most EU-level policies and Directives leave specific policy instrument designs to implement overarching requirements to the discretion of the Member States. In addition, Member States are able to introduce additional policy instruments unilaterally. As such, there is a deep divide between Member States in terms of the number of instruments in place, their ambition, sectoral coverage and broad optimality (Drummond, 2014).

The UK's Climate Policy Mix

The current climate mitigation policy landscape in the UK is described in Table 2, below, categorised into policy pillars and primary sectoral focus. Policy instruments in this instance have a broad definition and include instruments, initiatives, funds and organisations introduced, provided, operated, funded or owned (at least in part, directly or indirectly) by central government and with a nation-wide scope. All policies are currently active in some form (i.e. new entrants may be blocked, but the policy is still active), although policies for which a direct replacement has been announced have been removed in favour of the new policy (e.g. Renewable Obligation is replaced by Contracts-for-Difference (CfDs)). The list

does not include co-ordination bodies or overarching strategies and roadmaps, and where funds comprise sub-funds, the higher level of granularity has been provided where possible. EU-level funding opportunities are not included (such as the NER300 fund). The list is not exhaustive, but covers most instruments of significance across sectors and policy pillars. Numerous other policies exist in devolved administrations and local authorities, but are not considered here.

Table 2 - UK Climate Policy Landscape

	Policy Instrument/Scheme/Fund	Power	Industry	Buildings	Transport	Agriculture
Standards & Engagement	Emissions Performance Standard					
	CHP Focus					
	LSX Reporting Requirements					
	Energy Savings Opportunity Scheme					
	Ecodesign Requirements					
	Labelling for Energy-Related Products					
	Energy Company Obligation					
	Smart Meter Roll-Out					
	Microgeneration Certification Scheme					
	Building Minimum Energy Performance Standards (inc. Zero Carbon Homes Policy)					
	Code for Sustainable Homes					
	Energy Performance Certificates					
	Energy Saving Trust					
	Non-Domestic Energy Efficiency Training Fund					
	CO ₂ intensity standards for Passenger Cars & LGVs					
	Passenger Car Labelling					
	Logistics Carbon Reduction Scheme					
	'Go Ultra-Low' Campaign					
Agriculture Greenhouse Gas Action Plan						
Markets and Pricing	EU ETS					
	Carbon Price Floor					
	Climate Change Levy					
	Climate Change Agreements					
	Enhanced Capital Allowances					
	CRC Energy Efficiency Scheme					

	Vehicle Excise Duty					
	Fuel Excise Duty					
	Air Passenger Duty					
Strategic Investment	Contracts-for-Difference					
	Feed-in Tariffs					
	Capacity Market					
	Electricity Demand Reduction Pilot					
	Industrial Energy Efficiency Accelerator					
	Energy for Growth Project					
	CCS Commercialisation Competition					
	Cross-Government CCS R&D Programme					
	Offshore Wind Component Technologies Development and Demonstration Scheme					
	Carbon Trust Offshore Wind Accelerator					
	Marine Energy Array Demonstration Scheme					
	Nuclear Innovation Funding Schemes					
	Energy Storage Innovation Competitions					
	Low Carbon Networks Fund					
	Sustainable Power Generation and Supply Programme (SUPERGEN)					
	Energy Entrepreneurs Fund					
	Bioenergy Sustaining the Future Programme					
	Invest in Innovative Refurb Programme					
	Renewable Heat Incentive					
	Green Deal					
	Green Investment Bank					
	Salix Finance Public Energy Efficiency Loans					
Renewable Transport Fuel Obligation						
Plug-in Car and Van Grants						

	Plugged-in Places					
	Low Carbon Vehicle Innovation Platform					
	Local Sustainable Transport Fund					
	Green Bus Fund					
	Ultra-low Emission Taxis					
	National Rapid Charge Point Network					
	HGV Gas Refuelling Network					
	Polymer Fuel Cell Challenge					
	Government Buying Standards					
	Technology Strategy Board 'Catapult' Centres					
	The Energy Catalyst Fund					
	Advanced Propulsion Centre					
	Energy Technologies Institute					
	Knowledge Transfer Partnerships					

It is immediately clear from Table 2 that the climate policy landscape in the UK is broad and multifaceted, with a proliferation of instruments across sectors and the three pillars of policy. The fewest instruments are found in the markets and pricing pillar, whilst instruments for strategic investment are the most widespread. The sectoral spread is greatest and largely equal between the power, buildings and transport sectors, whilst Industry is subject to around half the instruments relevant to these sectors. Only five instruments are of potentially direct relevance to agriculture. Whilst this assessment provides information on the number of instruments, it does not consider details of instrument scope, design, ambition, impact or co-ordination, and thus is a first-stage, simplified assessment of the UK’s policy landscape. Nonetheless, it provides three useful illustrations. First, it provides a simple ‘snapshot’ regarding policy focus across sectors. For example, most instruments for the building sector fall under standards and engagement, whilst strategic investment is focussed on the power and transport sectors. Secondly, it serves to illustrate that the perceived preference in the UK for market-based solutions, minimal governmental intervention and ‘picking winners’ does not reflect the existing climate policy landscape. Mehling *et al* (2013) found similar such evidence. Thirdly, it confirms that the UK goes significantly beyond EU obligations in a number of ways. The principal example is the unilateral Carbon Price Floor (CPF) in the power sector, although the majority of identified instruments for strategic investment in low-carbon technologies, infrastructure and innovation are also unilateral policies, driven by a domestic agenda rather than an imposed requirement. Whilst it could be argued that some instruments exist to cost-effectively meet overarching requirements for 2020 traded and non-traded sector CO₂ reductions required by the EU ETS and Effort Sharing Decision (406/2009/EC), these instruments largely focus on further enabling the deployment of existing low-carbon technologies and producing technological innovation, both of which would be unlikely to yield significant abatement prior to 2020. As such, it is likely other drivers such as the legally binding, unilateral 80% reduction in GHG emissions by 2050 (from 1990 levels) under the 2008 Climate Change Act, and the development of innovative technologies and industries to enhance the UK’s future competitiveness and market development, are more influential drivers.

Table 3, below, provides a judgement-based qualitative assessment of the coverage of different types of instruments between sectors, taking into account instrument design, scope (direct and indirect), ambition and interaction, and the potential for policy intervention. Key justifications behind these qualitative assignments follow.

Table 3 - Instrument Coverage by Sector and Pillar of Policy - Qualitative Assessment

	S&E	M&P	SI
Power	High	High	High
Industry	Low	Low	Low
Buildings	Medium	Medium	Low
Transport	Medium	High	Medium
Agriculture	Medium	Medium	Low

- The power sector is well represented by a range of instruments across all three policy pillars. The power sector Emissions Performance Standard (EPS) prevents the construction of new unabated coal-fired power stations, whilst the EU ETS, supported by the CPF, provides a unified explicit carbon price across the sector higher than experienced in other EU Member States. CfDs and Feed-in Tariffs (FiTs) in particular further encourage investment in low-carbon electricity, whilst several other instruments provide investment for infrastructure and innovation across a range of power sector technologies.
- Policy instruments are sparse across all pillars for industry sector. Whilst the EU ETS provides a unified carbon price, the value is low and benchmarking maintains a relatively significant level of free allowance allocation, with Climate Change Agreements (CCAs) providing a 90% discount on the Climate Change Levy (CCL). Instruments present in standards and engagement and strategic investment have relatively small scopes and limited ambition.
- There are a range of standards and engagement and strategic investment policies in the building sector, although the focus is largely on commercial and new buildings, and the energy efficiency and use of products. Relatively little focus is placed on the efficiency and decarbonisation of existing residential buildings, responsible for around 32% of final energy consumption in the UK in 2013 (DECC, 2014), with the 'Green Deal' the primary instrument targeting such aspects, performing well below expectations. Whilst residential energy consumers do not pay the CCL and receive a reduced-rate VAT (5%), providing a substantial energy subsidy (>£5 billion annually (Advani *et al*, 2013)), they bear the pass-through cost of the EU ETS (with the CPF) and feed-in tariffs.
- Fuel excise duty and air passenger duty both carry high implicit carbon prices (both diesel and petrol are over £200/tCO₂ (OECD, 2013)), whilst vehicle excise duty for cars is graded by CO₂ intensity. In addition, the UK is one of the few Member States in Europe to reform company car taxation arrangements in terms of CO₂-intensity to prevent its distorting effect (Maca *et al*, 2013). The EU-level CO₂ intensity for passenger cars and LGVs regulations provides significant coverage from the standards and engagement pillar, although this only impacts new vehicles and currently excludes HGVs. Strategic investment instruments are numerous, including the prominent Renewable Transport Fuel Obligation, although many are have limited scope.
- Energy-related agricultural CO₂ emissions are covered by the CCL, although reduced taxation on 'red' diesel provides a substantial subsidy. The 'Greenhouse Gas Action Plan (GHGAP) is a voluntary, industry-led initiative to promote uptake of cost-effective production efficiency measures. It is unclear yet what impact and level of engagement has been achieved (Drummond, 2013). Government-led strategic investment appears largely absent.

Further work is required to these categorisations and assignments are robust, including assessment of the scope, impact, interaction and side effects of these policy instruments, and the potential for policy action in each sector and pillar of policy. For example, the requirement for government-led strategic investment is reduced if private sector investment is proving sufficient in some sectors or sub-sectors. However, some initial suggestions for

improvements to the existing policy mix may be proposed (or re-proposed), based on this first-stage assessment.

UK Low-Carbon Policy Mix – Suggestions for Short to Medium-Term Improvement

The options for improvement presented below attempt both to rectify issues with existing instruments and to target areas of low instrument coverage identified above where instruments may play a positive role in mitigation. In doing so, these suggestions seek to improve the effectiveness, cost-efficiency and feasibility of the policy mix. The importance of long-term commitment and overarching strategies, although not addressed in this paper, is widely recognised as an important backdrop to an effective climate policy mix (Steel *et al*, 2014; del Rio & Tarancon, 2012) As such, the retention of the 2008 Climate Change Act and the five-yearly carbon budgets it requires, along with the advancement of the sectoral and technological roadmaps published by government and affiliated bodies, is an important precondition.

Markets and Pricing

- **EU ETS** – The UK should push for the introduction of a Market Stability Reserve (MSR) as soon as possible, rather than 2021 as proposed by the European Commission (2014b), to restore an effective carbon price. Full auctioning should also be extended to the industry sector, with competitiveness concerns addressed through compensatory action, discussed below. The CPF should remain until the proposed MSR enters into force, and removed thereafter.
- **'CCL+'** – a substantially revised CCL, termed 'CCL+' as proposed by Advani *et al* (2013) could resolve a number of issues. The first is a revision of the levy rates, which may be reformed to produce an equalised implicit carbon price across coal, natural gas and LPG. The rate for electricity should be calculated as the differential between the implicit carbon price for fossil fuels, and the value of the upstream explicit and implicit carbon price pass-through to electricity prices. The scope of the CCL+ could extend to all non-transport activities, including electricity (exemption already removed in order to implement the CPF), and residential energy consumption. EU ETS liabilities should be subtracted from the CCL+ rate, if the result retains a positive cost. CCAs should also be removed, to remove distortions. Evidence suggests little to no impacts of the CCL on the output or employment of firms subject to the full CCL (Martin, de Preux and Wagner, 2011), whilst further evidence suggests CCA targets have been easily achievable (Bowen & Rydge, 2011). In addition, CCAs currently cover many sectors that are not at risk of carbon leakage. Whilst many industries are energy intensive or trade exposed, both must be the case for risk of leakage to be present. For those sectors that remain at risk, the removal of CCAs and increases in effective carbon prices must be compensated by appropriate mechanisms (discussed below). The CRC, now redundant, should also be removed. As the resulting increase in domestic energy prices would also be highly regressive, and also require a compensation package (discussed below) The CCL+ carbon price could be aligned with those required to deliver respective carbon budgets – see

Advani *et al* (2013) for an illustrative assessment of the impacts of small, medium and large energy-intensive firms as a result of this proposed reform.

- **VAT on Domestic Energy** – The reduced rate of VAT imposed on domestic energy consumption (5% rather than 20%) amount to a subsidy worth over £5 billion annually (Advani *et al*, 2013). This should be removed over time, with the simultaneous introduction of a suitable compensatory mechanism. The combined impact on domestic electricity prices with increased VAT along with CCL+ liabilities and the pass-through of other costs such as RES-E support mechanisms would be significant. Burden shifting to latter liabilities to general taxation, as with the Renewable Heat Incentive, may therefore be an attractive option.

Such reforms, whilst economically efficient, would be relatively substantial and increase energy costs to almost all actors, making them politically difficult and highly regressive. Compensatory mechanisms must be introduced to counter this. The use of environmental taxation reform principles could be employed through the reduction of income and payroll taxes, for example. For low-income households, the additional revenue could be used to provide targeted funds for energy efficiency measures, whilst any residual revenue may be hypothecated for use in strategic investment options.

Standards and Engagement

- **London Stock Exchange GHG Reporting** – This instrument, which requires all UK companies listed on the main market of the London Stock Exchange, a European Economic Area market or whose shares are dealt on the New York Stock Exchange or NASDAQ to report on their GHG emissions in their annual Directors' Report, should be extended to other large companies. This option will be reviewed in 2015, for potential introduction in 2016.
- **Requirement for Energy Management Systems (EMS)** – The Energy Efficiency Directive (2012/27/EU) requires all large companies to undergo an energy audit at least every four years, implemented in the UK by the Energy Saving Opportunities Scheme (ESOS). Companies with a certified EMS are exempt from this requirement. By requiring all such companies in the UK to implement an EMS system, this requirement is satisfied whilst producing additional benefits associated with an EMS. The ESOS may then be removed.
- **Residential Minimum Energy Performance in Existing Stock** – From April 2018, minimum energy performance standards will apply to the private rented sector, with a minimum Energy Performance Certificate rate 'E' or above required. Such a requirement could be extended to properties when sold, with funding provision for those in which meeting minimum requirements would be prohibitively expensive. This could be linked with the Green Deal financing mechanism.
- **Expansion of the Energy Companies Obligation (ECO)** – Additional revenues from the increased domestic energy prices introduced under the reforms suggested above could

be recycled to directly fund additional energy efficiency measures in low-income households via the ECO mechanism already in place.

- **Vehicle CO₂ intensity Standards** – Alongside increasingly stringent standards for cars and LGVs, the UK should push for the introduction of CO₂ intensity targets for HGVs, as suggested by the European Commission (2014a), to complement existing schemes (such as the HGV Gas Refuelling Network).
- **Alternative-Fuel Vehicle (AFV) Awareness** - To further encourage the penetration of low-carbon vehicles into the market, initiatives such as the recent ‘go ultra-low’ campaign should be expanded to further increase awareness of the benefits of AFVs from their currently low levels (Element Energy, 2013).

Strategic Investment

- **Government Buying Standards (GBS)** – Procurement standards for central government could be expanded and tightened. For example, new cars purchased by central government must have a CO₂ intensity of 130gCO₂/km or below. This could be made stricter to encourage the purchase of ultra-low emission vehicles. The 2nd stage of the ‘Energy for Growth’ programme (renewable electricity power purchase agreements) should be expanded to cover an increasing proportion of the Crown Commercial Service’s long-term electricity procurement, and be subsumed into the wider GBS. Such standards may also be made mandatory over time in local authorities, which are at present only encouraged to apply these criteria.
- **Funding and Investment Co-ordination and Consolidation** – It is clear from Table 2 that a number of different policies, funds and initiatives are in effect to promote low-carbon innovation, with many different sources of implementation (e.g. government departments and agencies), with some focussing on overlapping issues (e.g. the Carbon Trust’s Offshore Wind Accelerator, the Offshore Wind Component Technologies Development and Demonstration Scheme and the Technology Strategy Board’s Offshore Renewable Energy Catapult). Whilst the government’s Low Carbon Innovation Co-ordination Group (LCICG) aims to ensure such investment is co-ordinated, there may be scope for consolidation of funds from different sources to facilitate such action, and to potentially achieve increased funding and leverage for investment in priority innovations.
- **Expansion of the Role of the Green Investment Bank (GIB)** – There may be potential for a number of initiatives provided by other departments, agencies and organisations to be brought under the remit of the GIB. For example, the function of Salix Finance, which provides interest-free loans to public sector organisations for energy efficiency investments and is core-funded by five different government sources, may be provided by the GIB or a funded intermediary (such as with the Smart Energy finance vehicle for energy efficiency loans to SMEs, and the Green Deal Finance Company). Low-interest loans for AFVs may also be provided through similar means. Such provision by the

Scottish Energy Saving Trust, which provides an interest free loan for electric vehicles of up to £50,000, would no longer be required whilst provision for Plug-in Car and Van Grants could also be reduced and eventually removed. Ensuring effective co-ordination between the LCICG and the GIB may also help to ensure innovations are able to bridge the 'valley of death' between demonstration and early commercialisation.

Impact of Recommendations on 'Optimality' of Policy Mix

Environmental Effectiveness

Under these proposals, the expanded requirement for the development of more efficient buildings and vehicles, along with expanded and tightened GBS 'pushes' the market towards higher efficiency and decarbonisation, whilst an equalised and largely higher carbon price signal to much of the economy (including price stability in the traded sector), improved awareness of low-carbon vehicles and opportunities for organisational and process efficiencies along with improved access to finance, acts to 'pull' the system in the same direction. Encouraging decarbonisation from both directions helps ensure that in the case of underperformance of one instrument, another provides support to continue support for the transition. An existing example is again that between the EU ETS and Renewable Energy Directive. Whilst the price signal of the former has been low and volatile, the latter ensured the deployment of renewables continued (Drummond, 2013). Other complementarities also exist, such as the prevention of a rebound effect from improved efficiency.

Economic Efficiency

The imposition of an equalised carbon price across major sectors of the energy system improves static efficiency, although the imposition of regulations and standards broadly reduces it. Although, dynamic efficiency improves in both instances if prices predictably increases, and standards and regulations predictably tighten over time. The use of information instruments, such as the expanded large-company GHG reporting requirements, helps overcome information asymmetries whilst increasing the probability of the identification and implementation of cost-effective efficiency measures, reducing the energy efficiency 'gap'. The increase in energy prices would be highly regressive without compensatory mechanisms, although the recycling of revenues to energy efficiency measures and reduced labour taxation could prove progressive depending on the specific design (Advani *et al*, 2013). This may also act to reduce the incidence of fuel poverty and the need for related funds, such as the warm home discount, warm homes healthy people fund, cold weather payments and winter fuel payments, whilst simultaneously stimulating the energy efficiency industry. Reduced labour costs to employers may also induce a double dividend effect (Schöb, 2003). Co-ordinated strategic investment, including funding for innovation, contributes to dynamic efficiency of the policy mix, prevents increasing high-carbon lock in, and may induce a first-mover advantage for domestic industries.

Feasibility

The feasibility of each of the measures proposed is dependent on a number of factors, not least the fluctuations of the political economy. The introduction of mechanisms by which energy costs are increased, however, are likely to face resistance from all quarters. As such, revisions to the CCL in particular should take place over time to allow time for adjustment and for compensatory mechanisms to take effect. Despite the increase in cost over time, predictability of liabilities over time is likely to be welcome to industry and investors. Careful policy labelling, along with the active promotion of compensatory mechanisms, help to increase public and political acceptability of policy instruments (Zvěřinová *et al*, 2014). For example, a number of the proposals above could be framed (at least in part) as measures designed to reduce fuel poverty and excess winter deaths (and potentially, therefore, a healthcare issue), the promotion of energy efficiency to reduce energy demand in order to increase energy security and reliance on foreign imports, or to stimulate economic growth by providing markets and space for growth for new industries. Such labeling may elicit more active public and political than the framing of a climate policy instrument. Other political objectives, such as an increase in the proportion of revenue sought from environmental taxation, are also served by these proposals. By removing the CRC and CCAs, bringing currently diffuse finance resources under the remit of the GIB, and the continued tightening of strategic investment co-ordination reduces the administrative burden to all parties involved.

However, a number of barriers besides political and public acceptability would have to be overcome to enable these proposals. For example, as the GIB is fully publicly owned, its debt appears on the government's balance sheet, and therefore may appear to increase the public deficit. For this reason, the GIB is not able to borrow on capital markets to boost its resources until 2015/16, and until government debt falls as a percentage of GDP (Ares & Hirst, 2014). This prevents any significant increase the GIB's remit in the short to medium term.

Conclusions

To produce extensive decarbonisation of the economy, the European energy system (and by extension those of its Member States), require transformational changes over the coming decades. Public policy, an essential driver, must be implemented across three pillars of standards and engagement, markets and pricing and strategic investment, to address the three 'domains of change' of 'satisficing', 'optimising' and 'transforming'. In doing so, the policy mix must be as effective, cost-efficient and feasible as possible, although trade-offs between each of these aspects is unavoidable. Although key aspects of the EU climate policy mix appear to have been broadly effective and possibly produced macroeconomic benefit, the true EU climate policy mix is extremely varied, with Member States meeting obligations through different policy instruments, and introducing numerous additional unilateral instruments.

By dissecting the UK's climate policy landscape along the lines of policy pillars and sectoral focus, some general conclusions may be drawn. Whilst the UK has a plethora of instruments

spanning each of the three pillars of policy with primary focus across the five key sectors of power generation, industry, buildings, transport and agriculture, most instruments for the building sector, for example, fall under standards and engagement, whilst strategic investment is focussed on the power and transport sectors. It also appears that the perceived preference in the UK for market-based solutions, minimal governmental intervention and 'picking winners' does not reflect the existing climate policy landscape. Additionally, it is clear that the UK policy landscape goes well beyond direct EU obligations.

Several potential options exist to improve the existing policy mix along the three pillars, which may simultaneously improve its effectiveness, cost-efficiency and feasibility. Examples include a revised and expanded Climate Change Levy, the removal of reduced rate VAT on domestic energy, a requirement for Energy Management Systems and mandatory GHG reporting for large companies, and an expanded role for the Green Investment Bank. Such developments may significantly increase the rate of decarbonisation of the UK's energy system, have progressive impacts if delivered with appropriate compensatory mechanisms and reduce administrative burden by removing now-redundant parallel instruments. Other objectives, such as the reduction of fuel poverty and increasing revenue from environmental taxes, may also be achieved in tandem. Further work is required to systematically assess the interaction between policy instruments in the UK, and the potential and desirability for policy instruments across the three pillars in each of the five sectors. Further analysis of the policy proposals presented, including quantification where relevant, and an assessment of potential barriers, is also required.

Acknowledgement – The authors gratefully acknowledge funding provided by the European Union's Seventh Framework Programme for Research project CECILIA2050 (Grant Number: 308680).

References

Advani, A., Bassi, S., Bowen, A., Fankhauser, S., Johnson, P., Leicester, A., Stoye, G. (2013) *Energy Use Policies and Carbon Pricing in the UK*, London, Institute for Fiscal Studies

Agnolucci, P and Drummond, P (2014) *The Effect of Key EU Climate Policies on the EU Power Sector: An analysis of the EU ETS, Renewable Electricity and Renewable Energy Directive*, London, University College London

Ares, E. and Hirst, D. (2014) *Green Investment Bank*, Standard Note SNSC-5977, House of Commons Library

Bowen, A. and Rydge, J. (2011) *Climate Change Policy in the United Kingdom*, Organisation for Economic Co-operation and Development Economics Department Working Paper no.886

Branger, F. and Quirion, P. (2013) *Understanding the Impacts and Limitations of the Current Instrument Mix in Detail: Industrial Sector*, Paris, Centre International de Recherche sur l'Environnement et le Développement

CECILIA2050 (2013) *Current EU Climate Policy: An Optimality Assessment*, [Online] Available at:
http://cecilia2050.eu/system/files/CECILIA2050_Policy_Brief_No1_Stocktaking_Nov2013.pdf

DECC (2014) *Energy Consumption in the UK (2014)*, London, Department of Energy and Climate Change

Drummond, P. (2014) *Understanding the Impacts & Limitations of the Current EU Climate Policy Instrument Mix*, London, University College London

Drummond, P. (2013) *Country Report: The European Union*, London, University College London

Element Energy (2013) *Pathways to High Penetration of Electric Vehicles*, Cambridge, Element Energy Limited

European Commission (2014a) *Communication from the Commission to the Council and the European Parliament: Strategy for Reducing Heavy-Duty Vehicles' Fuel Consumption and CO2 Emissions*, Brussels, European Commission

European Commission (2014b) *Decision of the European Parliament and of The Council concerning the Establishment and Operation of a Market Stability Reserve for the Union Greenhouse Gas Emission Trading Scheme and Amending Directive 2003/87/EC*, Brussels, European Commission

European Commission (2013) *Report from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions – Renewable Energy Progress Report*, Brussels, European Commission

European Commission (2008) *Impact Assessment – Document Accompanying the Package of Implementation Measures for the EU’s Objectives on Climate Change and Renewable Energy for 2020*, Brussels, European Commission

European Environment Agency (2014) *EEA Greenhouse Gas Data Viewer*, [Online] Available at: <http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer> [Accessed 26th August 2014]

Frondel, M., Ritter, N., Schmidt, C.M., Vance, C. (2010) Economic Impacts from the Promotion of Renewable Energy Technologies: The German Experience, *Energy Policy*, 38, 4048-4056

Grubb, M. (2014) *Planetary Economics: Energy, Climate Change and the Three Domains of Sustainable Development*, London, Routledge

Hardy, B. (2007) How Positive Environmental Policies Affected Europe’s Decision to Oppose and the Adopt Emissions Trading, *Duke Environmental Law and Policy Forum*, 17(2), 297-318

Kuik, O. and Kalfigianni, A. (2013) *Food and Agriculture: The Current Policy Mix*, Amsterdam, Institute for Environmental Studies

Kuik, O., Branger, F., Quirion, P. (2013) *International Competitiveness and Markets*, Amsterdam and Paris, Institute for Environmental Studies and Centre International de Recherche sur l’Environnement et le Developpement

Martin, R., de Preux, L.B., Wagner, U.J. (2011) *The Impacts of the Climate Change Levy on Manufacturing: Evidence from Microdata*, National Bureau of Economic Research Working Paper Series, 17446

Maca, V., Eberle, A., Pearson, A., Ridgway, M., Braun Kohlova, M., Gorchach, B., Novak, J., Scasny, M. (2013) *Climate Policies and the Transport Sector: Analysis of Policy Instruments, their Interactions, Barriers and Constraints, and Resulting Effects on Consumer Behaviour*, Berlin, Ecologic institute

Meyer, B. and Meyer, M. (2013) *Impact of the Current Economic Instruments on Economic Activity: Understanding the Existing Climate Policy Mix*, Osnabruck, Gesellschaft fur Wirtschaftliche

OECD (2013) *Taxing Energy Use*, Paris, Organisation of Economic Co-operation and Development

del Rio, P. and Tarancon, M.A. (2012) Analysing the Determinants of On-Shore Wind Capacity Additions in the EU: An Econometric Study, *Applied Energy*, 95, pp.12-21

Schöb, R (2003) *The Double Dividend Hypothesis of Environmental Taxes: A Survey*, CESIFO Working Paper no.946

Solano, R. & Drummond, P. (2014) *Techno-Economic Scenarios for Reaching Europe’s Long-Term Climate Targets Using the European TIMES Model (ETM-UCL) to Model Energy System Development in the EU*, London, University College London

Steel, J., Barbose, G.L., Wiser, R.H. (2014) An Analysis of Residential PV System Price Differences between the United States and Germany, *Energy Policy*, 69, 216-226

Zvěřinová, I., Ščasný, M., Kyselá, E. (2014) *What Influences Public Acceptance of the Current Policies to Reduce GHG Emissions?*, Prague, Charles University Environment Centre