CECILIA 2050

OPTIMAL EU CLIMATE POLICY

Choosing Efficient Combinations of Policy Instruments for Low-carbon development and Innovation to Achieve Europe's 2050 climate targets

Short-term Improvements for an Effective, Cost-Efficient and Feasible Policy Mix

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LIST OF ABBREVIATIONS

ACER	Agency for the Co-operation of Energy Regulators
AFV	Alternative-Fuelled Vehicles
BAT	Best Available Technology
BCA	Border Carbon Adjustment
CAP	Common Agricultural Policy
CCC	Committee on Climate Change
CCS	Carbon Capture and Storage
CEF	Connection Europe Facility
CoM	Covenant of Mayors
DSO	Distribution System Operator
EED	Energy Efficiency Directive
EEOS	Energy Efficiency Obligation Scheme
EFSI	European Funds for Strategic Investment
EIB	European Investment Bank
EIPP	European Investment Project Portal
EIT	European Institute of Innovation and Technology
EITE	Energy Intensive, Emission Exposed
ENTSO-E	European Network of Transmission System Operators - Electricity
EPC	Energy Performance Certificate
EPS	Emission Performance Standard
ER2050	Energy Roadmap 2050
ERA	European Research Area
ESD	Effort Sharing Decision
ETD	Energy Taxation Directive
EU ETS	European Union Emission Trading System
FCP	Forward Commitment Procurement

GHG	Greenhouse Gas
GPP	Green Public Procurement
HGV	Heavy Goods Vehicles
JRC	Joint Research Centre
KAP	Key Action Point
KICs	Knowledge and Innovation Communities
KPI	Key Performance Indicator
LCPD	Large Combustion Plant Directive
LGV	Light Goods Vehicles
LRF	Linear Reduction Factor
LULUCF	Land Use, Land Use Change and Forestry
MEPS	Minimum Energy Performance Standard
MSR	Market Stability Reserve
NEDC	New European Driving Cycle
NEEAP	National Energy Efficiency Action Plan
NER	New Entrant Reserve
NRAP	National Renewable Energy Action Plan
NZEB	Near Zero Emission Buildings
OBA	Output-Based Allocation
PCI	Projects of Common Interest
PTP	Personalised Travel Planning
R&D	Research and Development
R&I	Research and Investment
RED	Renewable Energy Directive
RES-E	Renewable Energy Source - Electricity
SCC	Social Cost of Carbon
SEAP	Sustainable Energy Action Plan
SETIS	Strategic Energy Technology Information System

TCO	Total Cost of Ownership
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
ULEV	Ultra-Low Emission Vehicle
UNFCCC	United Nations Framework Convention on Climate Change
WFD	Water Framework Directive
WTLP	Worldwide harmonised Light vehicle Test Procedure
WTO	World Trade Organisation

Executive summary

The existing climate policy mix is uneven, both in terms of coverage and stringency, within and between sectors and Member States. Despite this, it has delivered relatively substantial CO_2 abatement, with a positive overall impact on both GDP and employment, with no evidence of induced carbon leakage. Whilst economic instruments have been important, they are not exploiting their full potential as a result of design flaws, insufficiently managed interactions with other instruments, and the presence of market distortions. Instead, regulatory instruments have thus far delivered a substantial proportion of policy-induced abatement. 'Non-Climate' instruments, and non-policy drivers, have also had a noticeable impact on GHG emissions in some sectors. Broadly speaking, 'information' instruments have thus far had little influence on driving low-carbon investment and behaviour changes. Instruments of all descriptions, both at EU and Member State level, are often not designed to deal with or correct for unexpected developments or side effects, producing sub-optimal or even counterproductive outcomes, and reducing credibility. Additionally, Institutional and legal configuration, characteristics and procedures at both EU and Member State level has a substantial influence over whether an instrument or instrument mix is effective, or feasible to introduce in the first place.

In order to achieve the objective of a reduction in GHG emissions of 80% in the EU by 2050 (from 1990 levels), the rate of abatement across all sectors must decrease substantially, driven by a comprehensive, effective, cost-efficient yet feasible instrument mix, and facilitated by appropriate governance and institutional structures and processes. Such instruments and reforms must meet or overcome ten key challenges in both the short- and long-term:

- Establish a Meaningful Carbon Price
- EU-Wide Electricity Market Reform and System Integration
- Make Sounds Infrastructure Choices Despite Technological Uncertainty
- Provide Finance and Mobilise the Investments Necessary for a Low-Carbon Economy
- Encourage Low-Carbon Lifestyles
- 'Fully' Decarbonise the Power Sector
- Facilitate Low-Carbon Transport
- Tackle the Energy Consumption of the Housing Stock
- Stimulate Radical Low-Carbon Innovation in Industry
- Address non-CO_2 Greenhouse Gas Emissions, Particularly from Agriculture

Various options are presented to meet, or lay the foundations and trajectory towards meeting these challenges in the short-term (by 2030). In terms of '**framework' conditions, and the reform and operation of public institutions**, key examples include maximising the potential benefits of EU-wide, supranational initiatives such as the Energy Union and Innovation Union concepts, along with leveraging the potential for subnational and regional governance initiatives (such as the Covenant of Mayors), to facilitate and encourage the emergence synergies, ‘frontrunners’ and ‘policy labs’ at all levels of governance. This is supported by the ‘mainstreaming’ of the low-carbon objective across all areas of policy making and investments made by public funds, or by public financial institutions. Indeed, dedicated funds and instruments for low-carbon development and innovation should be stepped up, at both the EU and Member State level. Ensuring clear and appropriate spatial planning regimes and administrative competences, perhaps unified in a single body at all relevant levels of jurisdiction, may overcome the need for several complex, unclear and disjointed processes, in turn reducing administrative barriers to the development of low-carbon infrastructure. The production of long-term plans by Member States helps highlight potential synergies between proposed low-carbon development pathways, helps identify and avoid conflicts before they occur, and helps recognise key areas of uncertainty for future focus. Increasing the application of monitoring and enforcement mechanisms, at both EU level and by Member States, would also likely prove beneficial.

In terms of broad policy instrumentation, two broad pathways are presented. The first is the **‘incentive-based’ policy pathway**, which focuses on pricing and other technology-neutral incentivising instruments to drive low-carbon investments and behaviour. A strengthened EU ETS, expanded to cover the residential heating sector, is the primary instrument and cornerstone of the instrument mix. This is supported by the introduction and harmonisation of a carbon price in the (road) transport sector, through CO_2-based vehicle registration and circulation taxes, and CO_2-based road pricing. Existing regulatory requirements and targets largely remain, but are generally not tightened, and many expire once time-limited targets are met. The second pathway is the **‘technology-specific’ policy pathway**, which focuses on regulatory targets and limits, and instruments that encourage particular technologies. Market-based elements remain a strong feature, and may often be used to accelerate the development or increase the deployment of particular technologies. The role of pricing instruments is secondary in this pathway, and many existing ‘incentivising’ instruments (e.g. vehicle registration taxes), may be removed over time from a climate policy perspective.

However, regardless of the specific policy pathway taken, various **cross-cutting options** for the introduction of new and the reform of existing policy instruments are available. This includes the reform, where appropriate, of renewable support mechanisms and capacity mechanisms to ensure effectiveness, cost-efficiency and sustainability for as long as such mechanisms are likely to be required. Additionally, existing information instruments, which have had relatively little influence thus far, may be amended to ensure they present clear, reliable and appropriate information, whilst new information instruments may be introduced where they have thus far been underexploited. This includes the use of ‘soft’ transport measures, and potentially a ‘food to fork’ GHG accounting system for the integrated agri-food sector. Actions to reduce market distortions, such as those presented by company car taxation rules in many Member States, may also be taken.

Broadly, whichever policy pathway is taken and specific options implemented, **the design of individual instruments (both existing and new) and instrument mixes, and associated**

governance approaches, must be 'smarter', in order to deal with uncertainty, improve stability and increase confidence. Such an approach may be summarised into five key criteria; (a) Effective instrument targeting, (b) Effective monitoring/compliance mechanisms, (c) allows for future revision if required, (d) able to deal with changing circumstances (both expected and unexpected, and (e) Inducement and promotion of positive co-benefits.

1 Introduction

The EU has set itself an ambition to reach a reduction in GHG emissions of 80-95% by 2050, from 1990 levels. Between 1990 and 2012, GHG emissions reduced by around 20% (European Environment Agency, 2015b). If the 2050 target is to be achieved, the rate of emission reductions must therefore increase substantially. Whilst the evidence suggests that the EU and Member State climate policy mix made a relatively significant contribution to the emission reductions achieved so far (particularly in the latter years), to achieve the step-change required, it must be substantially strengthened. It must also achieve its goal as cost-efficiently as possible. However, any effort to implement a strengthened, cost-effective policy mix (and the institutional reforms required to enable it), it must move beyond theoretical arguments and consider 'feasibility'; including the existing complement of policy instruments and institutional arrangements, political and public acceptability, legal compatibility and administrative capabilities.

The objective of this report is to present options for the reform of the existing EU climate policy mix and institutional architecture, to improve its effectiveness and cost efficiency, within the bounds of 'feasibility' as described above. Essentially, it seeks to achieve 'optimality' using a broad definition employed by the CECILIA2050 project (and described in Section 5.2), which moves beyond the traditional definition. It focuses on short-term changes; those that may be introduced up to 2030, and establishes the basis for further abatement and policy development in the longer-term (to 2050).

Section 2 first discusses the general composition, achievements and limitations of the existing EU climate policy mix, key institutional aspects and initiatives that concern such policy, and basic technical and policy requirements for the future. Section 3 then presents the ten key decarbonisation 'challenges' that must be met or overcome to enable a successful low-carbon transition to develop, along with the 'status quo' from which any reform options must depart. Section 4 follows with instrumentation and institutional reform options for how to meet and overcome these challenges, drawn together in Section 5 by how these options together achieve these objectives. Section 6 concludes.

2 The Current Climate Policy Mix – Composition, Achievements and Limitations, and Requirements for the Future

2.1 The Current Climate Policy Landscape

2.1.1 Composition, Effects and 'Lessons Learned'

This section provides a brief overview of the current landscape of climate policy in the EU, what it has and has not achieved thus far, and where key limitations may be found. A more detailed description and discussion may be found in Drummond (2014)[1], and in Section 3, concerning specific ‘challenges’, below.

The existing climate policy mix is uneven, in terms of both coverage and stringency, within and between sectors and Member States.

The power and industry sectors experience the most coherent policy landscape, with the EU ETS producing a single, EU-wide carbon price across these sectors. However, the combination of the economic crisis (and resulting fall in emissions), generous use of international offset credits, and the success of complementary policies (such as renewable electricity (RES-E) support mechanisms) have rendered the EU ETS largely ineffective as a driver for abatement, as evidenced in the substantial allowance surplus and the resulting low price. 27 of 28 Member States also promote the deployment of renewables in the power sector through dedicated support mechanisms (with highly varied design and level of support) (Agnolucci and Drummond, 2014).

In the buildings sector, EU-level policy has focussed largely on new buildings, with high apparent ambition, but low effective implementation by Member States. Existing buildings have only recently become directly subject to EU-level policy focus, with implementation yet to be achieved in many Member States. However, instruments addressing components of energy consumption and emissions from buildings, such as energy-using and energy-related products, have been in place for some time, and have been relatively effective (Drummond, 2013). In transport, several instruments act on passenger cars, with other road-based vehicles and non-road transport modes (such as aviation and shipping) subject to little if any policy instrumentation. No explicit climate policy instrumentation exists at the EU level for the agriculture sector (and few for non-CO_2 GHG more broadly). Instruments that do exist are at the Member State level, are largely recent introductions, focus on information dissemination and R&D rather than direct emissions abatement, and are implemented on a voluntary basis (Kuik and Kalfagianni, 2013).

Despite this, the existing climate policy mix has delivered relatively substantial CO_2 abatement, with a positive impact on both GDP and employment at the EU level.

Econometric modelling suggests that the presence of the EU ETS, renewable electricity support mechanisms and environmental tax reforms across the EU reduced CO_2 emissions by up to 12-13% in some Member States against the counterfactual, in 2008 (with substantial variation). This value would likely increase when considering the impact of flanking instruments. In combination, it is clear that these instruments did not have a negative impact on EU GDP in 2008, and likely had a positive impact. Similarly, employment was also likely higher than in the counterfactual scenario. However, substantial variation between Member States is present (Meyer and Meyer, 2013).

[1] This report summarises a series of reports produced under the CECILIA2050 project, each of which assesses the impact of the current climate policy mix on individual sectors, or cross-sectoral aspects.

There is no evidence to suggest that 'carbon leakage' has occurred.

Whilst much *ex-ante* analysis predicted the EU ETS would lead to a substantial loss of competiveness producing carbon leakage (of between 5-20%), no evidence suggests that any carbon leakage has yet occurred. This may be due to various reasons, including (a) the presence of anti-leakage measures, such as free allocation of permits, (b) the low price experienced for much of the EU ETS' history, (c) the relative importance of other factors such as labour force qualification, infrastructure quality and proximity to customers (d) characteristics such as capital intensity determining how 'footloose' an industry is, or (e) non-consideration of policy-induced impacts such as first-mover advantages, 'spillover' effects, and induced innovation (Branger and Quirion, 2013; Kuik *et al*, 2013).

Non-'climate' instruments, and non-policy drivers, have also had a noticeable impact on GHG emissions in some sectors.

GHG emissions from the agriculture sector have decreased by over 20% since 1990 (particularly CH_4 and N_2O). This has been driven by a combination of provisions in instruments introduced for non-climate reasons, such as the Nitrates Directive, Water Framework Directive and Common Agricultural Policy (CAP), and non-policy drivers such as rapid increases in animal productivity in Central and Eastern Europe (Kuik and Kalfagianni, 2013). In the power sector, the Large Combustion Plant Directive (LCPD) has likely had some impact in advancing the closure of coal-fired power stations (Agnolucci and Drummond, 2014). More broadly, the financial crisis is likely to have had a substantial impact on CO_2 emissions across different sectors.

Whilst economic instruments have been important, regulatory approaches have delivered a substantial proportion of abatement induced by the policy mix.

The EU ETS reduced CO_2 emissions by around 1-3% in most Member States (in 2008), almost entirely through temporary 'fuel switching' from coal to gas in the power sector. The deployment of renewables in the power sector is driven by dedicated support mechanisms (often through market-based instruments), producing around 3.5% CO_2 abatement on average across Member States in 2008 (Drummond and Agnolucci, 2014; Meyer and Meyer, 2013). In the road transport sector, regulations for passenger cars have been successful in reducing fleet-average CO_2 intensity of new vehicles in recent years, with the 2015 regulatory target achieved early. In the buildings sector, minimum energy performance standards on energy-using and energy-related products (through the Ecodesign Directive) have likely been instrumental in shifting the market to more efficient products for lighting, heating and cooling equipment, white goods and other appliances (Drummond, 2013).

Economic instruments are not exploiting their full potential as a result of design flaws, interactions with other instruments, and the presence of market distortions

Design flaws often centre on a lack of flexibility or capacity to deal with uncertainty, discussed below. The overlap of economic instruments in combination with regulatory approaches, in some instances, is likely to have increased costs without generating additional emission reductions. For example, subsidies for the purchase of new low-carbon passenger cars, as present in many Member States, are largely superfluous in the presence of EU-wide CO_2 intensity fleet standards. However, the often-cited overlap (and resulting inefficiency) between dedicated renewable electricity support mechanisms and the EU ETS is not as problematic as it is made out to be, since the 2020 renewable deployment target was considered in the EU ETS cap-setting (Drummond, 2013).

Market distortions are often significant. Tax arrangements for company cars in many Member States are such that the purchase of highly-CO_2 intensive cars are incentivised, whilst the driver of the vehicle is not liable for fuel costs. As such, the effects of fuel taxation and other market-based instruments to encourage reduced CO_2 emissions are substantially dulled. Additionally, fuel taxes and levies vary substantially across Member States. This produces tax competition and fuel tourism, particularly for long-distance freight vehicles, creating additional CO_2 emissions and undermining the effect of fuel taxation in a given Member State (Maca *et al*, 2013). Under existing legal frameworks, fuel for residential heating and agricultural application are exempt from taxation (Drummond, 2013). In addition, some Member States provide other energy consumption subsidies that also act to reduce the effects of pricing instruments. For example, reduced-rate VAT is applied to residential heating fuels in the UK (5% rather than the standard rate of 20%). This constitutes an annual implicit subsidy of around £5 billion (Advani *et al*, 2013). In many Member States, electricity prices for residential consumers continue to be tightly regulated at a low level.

Information instruments (e.g. labelling) have thus far had little influence on driving low-carbon investment and behaviour changes.

There are four broad contributing factors to this insight. Firstly, the target audience (e.g. consumers) are often simply unaware of the instrument in the first place. Secondly, if they are aware, understanding of the information presented is often low. This links to the third aspect of instrument design, which often allows for confusion, misinterpretation, or otherwise does not provide information required to maximise the potential of such an instrument. The final aspect concerns priorities of the target audience and the existing incentive framework. Cognitive complexities (such as discounting future costs and benefits) or other priorities (capital costs, cultural preferences, etc.) often inhibit the effectiveness of information presented, compounding the lack of an appropriate economic incentive in the first place (Drummond, 2013).

Instruments are often not designed to deal with or correct for unexpected developments or side effects, producing sub-optimal or even counterproductive outcomes, and reducing credibility.

The key example is the EU ETS, which is currently experiencing a substantial surplus of emission allowances resulting (principally) from the economic crisis. This results in low carbon prices, which despite the adoption of the Market Stability Reserve, will likely persist for a number of years, rendering the EU ETS largely defunct as an instrument for driving low-carbon investment. RES-E support mechanisms in some Member States have been repeatedly altered to respond to specific concerns, particularly increasing overall costs of the system, overly generous rates as technology costs decreased, or conflict with state aid rules. This has produced legal challenges in some instances. In Spain, retroactive changes to tariff rates were introduced in response to spiralling costs, substantially reducing confidence in renewables investment (González-Eguino *et al*, 2013).

Institutional and legal configuration, characteristics and procedures at both EU and Member State level has a substantial influence over whether an instrument or instrument mix is effective, or feasible to introduce in the first place.

Unanimity in the European Council is required for the introduction of or substantial changes to instruments operating EU-wide and that are ‘primarily of a fiscal nature’. This has influenced the instrument choice in climate policy in the past, in particular favouring the EU ETS over an EU-wide carbon tax (Mehling *et al*, 2013).

Depending on administrative divisions, a number of entities may be responsible for, or have influence over, different elements of the climate policy mix or individual instruments, at both EU and national levels. This can lead to institutional conflicts that impede the implementation and coherence of policy instruments. In some Member States, sub-national governance levels are essential for effective implementation and operation of climate policies. Evidence suggests that this has both helped and hindered the implementation of low-carbon policies in different Member States (Bausch *et al*, 2015).

2.1.2 Overarching Targets and Initiatives

2.1.2.1 2030 Climate and Energy Package

The 2020 Climate and Energy Package, introduced in 2009, set the well-known ’20-20-20’ targets for GHG reduction, deployment of renewables and increase in energy efficiency. In January 2014 the European Commission proposed a 2030 Framework for Climate and Energy Policies. The European Council agreed the package in October 2014. As per the 2020 Package, the framework contains three key elements (European Commission, 2015a; European Commission, 2014a):

- **40% GHG emission reduction by 2030** from 1990 levels (delivered by an estimated 43% reduction in EU ETS emissions and 30% in non-ETS sectors, from 2005 levels), increased from a target of 20% by 2020. As per the 2020 Package, this is to be delivered via binding targets on Member States[2]
- **27% renewables in final energy consumption by 2030**, an increase from 20% in 2020, but ‘binding’ at the EU-level only. The main driver for this is expected to be an increase in renewable electricity generation from around 21% at present, to 45% by 2030.

[2] Yet to be assigned, but non-ETS targets are to be calculated in the same manner as for the 2020 Effort Sharing Decision (i.e. relative GDP per capita). Targets will set at between 0% and -40% from 2005 levels, for each Member State. Land Use, Land Use Change and Forestry (LULUCF) is not included in the 2020 Package, and inclusion is yet to be decided for the 2030 Package (discussed under Section 4.1.1.1).

- **27% increase energy efficiency by 2030**, against baseline projections for primary energy consumption – an increase from 20% in 2020. This target is 'binding' at EU-level only, and will be reviewed in 2020 for a potential increase to 30%.

Whilst the EU is broadly on track to meet the '20-20-20' targets by 2020 (driven by a combination of policy measures and exogenous factors), it is clear that the existing policy landscape is not sufficient to deliver the 2030 Framework targets (and certainly not the long-term ambition of a 80-95% reduction in GHG emissions by 2050) (European Environment Agency, 2015a). As such, the existing climate policy instrument mix, and supporting governance approaches and institutions, must be reformed and extended to match the level of ambition required in the short- and long-term.

2.1.2.2 The 'Energy Union'

In February 2015, the European Commission published its proposal for an 'Energy Union' – the implementation of which is one of the new Commission's overarching '10 Priorities'[3]. The objective of the proposed Union, broadly, is to 'bring greater energy security, sustainability and competitiveness', through five interrelated dimensions of (a) energy security, solidarity and trust, (b) a fully integrated European energy market, (c) energy efficiency contributing to moderation of demand, (d) decarbonising the economy, and (e) research, innovation and competitiveness (European Commission, 2015b). These 'dimensions' may be further broken down into fifteen proposed 'Action Points' (KAPs), many of which relate to the proposed options and directions for short-term reforms and instruments discussed in Section 4. As such, these KAPs will be discussed where appropriate. The first 'State of the Energy Union' report due in Autumn 2015, after which annual reporting is expected.

2.1.2.3 The Innovation Union

Launched in 2010, the 'Innovation Union' is one of the seven flagship initiatives of the Europe 2020 strategy for smart, sustainable and inclusive growth[4], and holds three key aims: (a) make Europe into a world-class science performer, (b) remove obstacles to innovation, and (c) revolutionise the way public and private sectors work together, notably through 'Innovation Partnerships'. These aims are to be delivered through 34 'action points', grouped into 13 broad titles. Each action point holds specific targets and timeframes for achievement. (European Commission, 2015r):

- **Promoting excellence in education and skills development** – train researchers, promote attractive employment conditions, ranking and benchmarking of university performance, creation of 'knowledge alliances'.

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[3] Along with 'Jobs, Growth and Investment', 'Digital Single Market', 'Internal Market', Economic and Monetary Union', 'EU-US Free Trade', 'Justice and Fundamental Rights', 'Migration', EU as a Global Actor' and 'Democratic Change'. See http://ec.europa.eu/index_en.htm for more information.

[4] The other six include: 'Digital Agenda for Europe', 'Youth on the Move', 'Resource Efficient Europe', 'An Industrial Policy for the Globalisation Era', 'An Agenda for New Skills and Jobs', and 'European Platform Against Poverty'.

- **Delivering the European Research Area (ERA**) – remove obstacles to mobility and cross-border co-operation of researchers and research organisations, and encourage dissemination, transfer and use of research results.
- **Focus EU funding instruments on Innovation Union priorities** – focus on Europe 2020 objectives, particularly societal challenges, and simplify access to funding (particularly to SMEs). Strengthen the base for policymaking through the Joint Research Centre (JRC), and create a 'European Forum on Forward Looking Activities'.
- **Promote the European Institute of Innovation and Technology (EIT) as a model of innovation governance in Europe** – creation of Strategic Innovation Agenda, including the creation of new Knowledge and Innovation Communities (KICs).
- **Enhancing access to finance for innovative companies** – EU financial instruments to attract private finance, enable venture capital funds to function and invest freely across the EU, and strengthen cross-border matching of innovative firms with suitable investors.
- **Creating a single innovation market** – EU and Member States to undertake screening of regulatory framework in key areas (including eco-innovation), to identify improvement requirements. Member States to set aside dedicated budgets for procurement of pre-commercial and innovative products and services totalling at least €10 billion ('Green Public Procurement', discussed in Section 4.1.2.6). An 'eco-innovation action plan' should be developed.
- **Promoting openness and capitalising on Europe's creative potential** – The Commission will promote open access to publicly funded research, and facilitate collaborative research and knowledge transfer. Development of European knowledge market for patents and licensing, and role of competition policy assessed.
- **Spreading the benefits of innovation across the Union** – Member States to improve use of Structural Funds for research and innovation projects (including trans-national projects).
- **Increasing social benefits** – social innovation to become a mainstream focus, with dedicated research programme on public sector and social innovation and the use of a European Public Sector Innovation Scoreboard.
- **Pooling forces to achieve breakthroughs: European Innovation Partnerships** – The Commission invites all stakeholders to commit to the innovation partnership concept, and to pool efforts and resources.
- **Leveraging policies externally** – The EU and Member States should contribute to global approaches and solutions to societal challenges, and the establishment of a level playing field. Agreement should be reached with international partners on the development of research infrastructures, which owing to cost, complexity and interoperability can only be developed on a global scale.
- **Reforming research and innovation systems** – Member States carry out self-assessments to identify key challenges and critical reforms, supported by the Commission through sharing of best-practice, peer reviews and development of the evidence base.
- **Measuring progress** – The Commission will monitor progress on these objectives and targets through the use of a Research and Innovation Union Scoreboard.

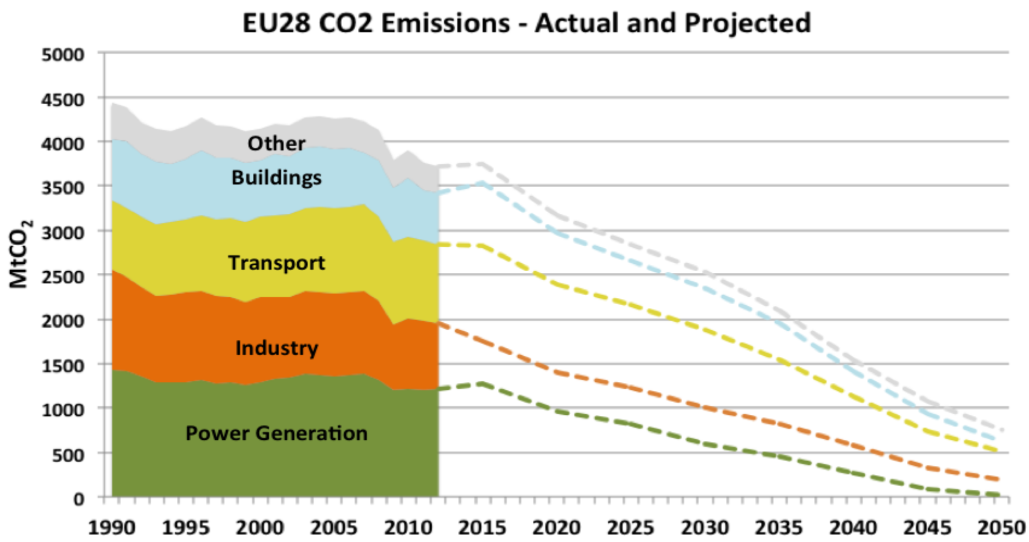
The Innovation union should also allow achievement of the overarching target of 3% GDP invested in Research and Development (R&D) by 2020 (delivered cumulatively by national targets, and divided between public investment (1%) and private investment (2%)) - one of the five targets of the Europe 2020 strategy[5]. Progress in achieving the objectives of the Innovation Union, and possible options for its future development, are discussed in Section 4.1.1.1.

2.2 Basic Requirements for the Future

2.2.1 Basic Requirements for GHG Reduction

The EU has committed to a long-term target of a reduction of GHG emissions of 80-95% by 2050, from 1990 levels. As discussed above, the EU is broadly on track to meet its intermediate 2020 targets for climate and energy, but requires additional effort to achieve its stated ambitions for 2030 and beyond. Figure 1 illustrates actual CO_2 emissions in the EU28 between 1990 and 2012 by sector, and projected CO_2 emissions to 2050 based on the EU's Energy Roadmap 2050 (ER2050) (European Commission, 2011b)[6].

Figure 1 - EU28 CO_2 Emissions - Actual (1990-2012) and Projected (2013-2050)



In 2012, the power generation sector accounted for the largest proportion of CO_2 emissions in the EU, at around a third (excluding LULUCF). The industry and (domestic) transport sectors accounted for around a fifth and a quarter, respectively, with buildings at around 16%. 'Other' emissions accounted for the remainder, at 8%. As is clear from Figure 1, CO_2

[5] The five targets are described in Footnote 55

[6] 'Industry' includes Manufacturing and Construction, and Industrial Processes. 'Transport' excludes international transport. 'Buildings' includes residential, commercial and institutional buildings. 'Other' includes emissions from fuel combustion in agriculture, forestry and fisheries, waste and other non-specified sources. Emissions exclude Land Use, Land Use Change and Forestry (LULUCF). ER2050 projection are based on the 'Diversified Supply Technology' Scenario.

emissions from all sectors must reduce significantly over the coming decades to achieve the stated overarching abatement goals.

In order to remain on the trajectory to the 2050 targets, the modelling work represented by Figure 1 suggests that CO_2 emissions from the power generation and industry sectors (plus 'other' emissions) should approximately halve by 2030 from 2012 levels, with CO_2 emissions from buildings reducing by 20%. Transport emissions remain stable. Such trends occur in the face of likely increases in demand for the services and products these sectors provide. In the long-term, more dramatic reductions occur. The power sector in particular, as illustrated in Figure 1, should almost completely decarbonise, whilst all other sectors reduce to around a third of their 2012 CO_2 emissions. Whilst the reduction of CO_2 emissions, which account for over 80% of all (non-LULUCF) GHG emissions in the EU (European Environment Agency, 2015b), must clearly be the focus of abatement efforts, non-CO_2 GHGs must also be tackled where feasible. More detail on the abatement required, and how they may be delivered through technological and behavioural changes, are discussed under the relevant 'challenges' presented in Section 3.

2.2.2 Basic Requirements for Climate Policy

Both theory and evidence suggests that a combination of climate policy instruments is essential, in a well coordinated 'instrument mix' in order to deliver the GHG reductions that are required in a cost-effective, feasible manner (Drummond, 2015). The landmark Stern Review on the Economics of Climate Change (or 'Stern Review'), considered that a policy framework for CO_2 abatement should have three elements: carbon pricing, technology policy and the removal of barriers to behaviour change (Stern, 2006). Grubb *et al* (2014) advanced this concept, as illustrated by Figure 2.

Figure 2 - Three 'Domains of Change' and 'Pillars of Policy' (Source: Grubb *et al*, 2014)

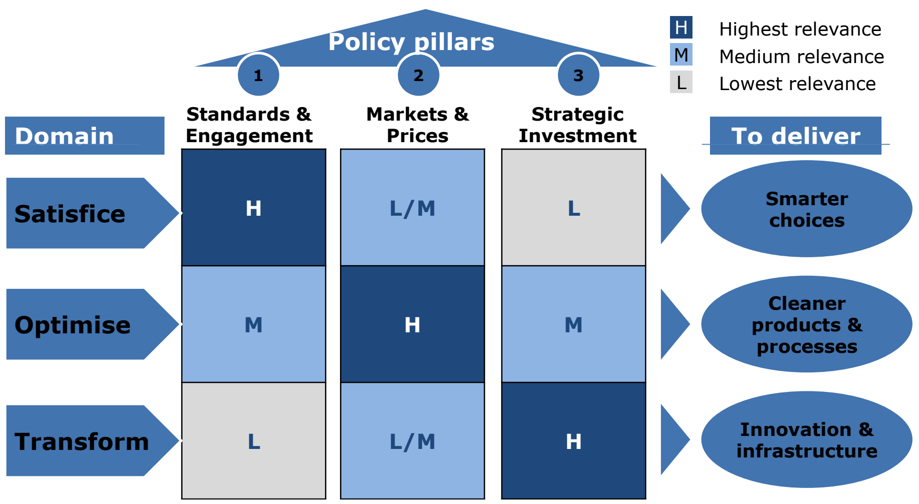


Figure 2 illustrates three 'domains of change' and corresponding 'pillars of policy'. Each domain of change reflects a distinct sphere of economic decision-making and development. The first, 'satisficing', describes the tendency of individuals and organisations to base decisions on habit, assumptions and 'rules of thumb'. Such phenomena link to behavioural and organisational economics, for which the first pillar of policy, 'standards and engagement', may be employed to produce 'smarter choices'. The second domain, 'optimising', describes the 'rational' approach of actors making 'optimal' choices 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', employs this framework to deliver 'cleaner products and processes'. The final domain, 'transformation', 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, in which 'strategic investment', delivers 'innovation and infrastructure' (Grubb, 2014).

Each of the three domains and pillars of policy, whilst presented as conceptually distinct, interact through numerous channels. As Figure 2 illustrates, whilst the impact is strongest in one, each of the pillars of policy have at least some influence on all three domains. All three domains, and by extension all three pillars of policy, are of largely equal importance in delivering a low carbon energy system and economy (Grubb, 2014).

However, the particular form instruments under each of these pillars of policy take, both individually and in combination, may vary substantially between Member States and over time, depending on the specific issues that require tackling, and the feasibility of different approaches (including public and political acceptability, legal compatibility and institutional structure and capacity).

3 Key Decarbonisation 'Challenges'

It is clear that in order to successfully achieve the EU's low carbon ambition in the short- and long-term, certain infrastructural and policy hurdles must be overcome. Section 3.1 describes five 'systemic' challenges that must be addressed. These challenges may be considered 'enablers' and broad drivers of a low-carbon transition, without which such a transition would be substantially more difficult to achieve, or only at a significantly higher cost. Section 0 describes four 'sectoral' challenges, which relate to issues surrounding specific sectors of the energy system and economy.

Given the nature of the challenges presented, many overlaps and interdependencies exist. Key overlapping issues are raised where relevant. Additionally, the challenges are not fully comprehensive, and do not necessarily directly address all issues that require attention. They are simply those that are considered to be of highest importance. However, many other issues are, by their nature, addressed directly or indirectly through these key challenges.

For each of the ten challenges, a discussion of the 'status quo' is provided (both in terms of the policy landscape and physical attributes, depending on the challenge), along with what broad aspects must be achieved or delivered for the challenge to be overcome.

3.1 Systemic 'Challenges' - Description and Status Quo

3.1.1 Establish a Meaningful Carbon Price

It is clear that a strong, credible carbon price must be a component of any policy package that aims to limit emissions in a cost-effective way. Carbon pricing is central to the second pillar of policy ('Markets and Pricing') illustrated in Figure 2, and is required to influence investment choices and prevent high-carbon lock-in.

As discussed under Section 2.1.1, the European Union Emissions Trading System (EU ETS) (Directive 2009/29/EC) is the primary carbon pricing instrument in the EU (plus Norway, Iceland and Lichtenstein), and covers CO_2 emissions around 11,000 stationary installations in the power and heavy industry sectors, accounting for around 45% of GHGs from the EU28 (European Commission, 2015)[7]. Combustion installations with a rated thermal input below 20MW are exempt. Both domestic and international aviation are also coved by the EU ETS, although compliance requirements for the latter are suspended until 2016[8].

As of the beginning of Phase 3 in 2013, permits are fully auctioned to the power sector (with temporary derogations in some Member States). In the Industry sector, permits are allocated based on product-specific 'benchmarks'. Each benchmark is calculated as the average emissions of the top 10% performing installations in the EU producing a given product. This means that installations that meet these benchmarks will receive free allocation sufficient to cover their total emissions, with those not meeting the benchmark receiving proportionally less. A further distinction is made between industries deemed to be at the risk of carbon leakage[9] – which currently receive 100% of the free allocation calculated on the basis of the benchmarks – and those not exposed to the leakage risk, which received 80% of the benchmark-based allocation in 2013, decreasing to 30% in 2020 (Drummond, 2015).

Whilst the permit price reached very high levels in the first year of operation in 2005, and again in 2008 at the start of the 2nd trading period (at around €25/tCO_2), prices have remained significantly lower since, and have experienced significant volatility (with prices remaining well below €10/tCO_2 since late 2011). As discussed under Section 2.1.1, such prices

[7] N_2O from the production of nitric, adipic, glyoxal and glyoxalic acids, and PFCs from aluminum production, is also covered.

[8] Domestic' aviation is defined as any flight internal to an Individual Member State, or any intra EU28+3 flight. 'International ' aviation is defined as any flight to or from any EU28+3 airport originating or terminating outside the EU28.

[9] Defined at 'energy-intensive, trade exposed' (EITE) industries. Sectors or sub-sectors qualify as EITE if 'the extent to which the sum of direct and indirect additional costs induced by the [EU ETS] would lead to an increase of production cost, calculated as a proportion of the Gross Value Added, of at least 5%; **and** the trade intensity (imports and exports) of the sector with countries outside the EU is above 10%. Sectors or sub-sectors are also deemed to be at significant risk of carbon leakage 'if the sum of direct and indirect additional costs is at least 30%, **or** the non-EU trade intensity is above 30%' (European Commission, 2015e).

have produced only relatively modest abatement, achieved almost entirely through temporary 'fuel switching' from coal to gas in the power sector. These low prices are the product of a substantial oversupply of permits in the system. Whilst various factors have contributed to this surplus, a significant factor is almost certainly reduced demand for electricity and industrial products (and therefore the emissions associated with generation and production), stemming from the 2008 financial crisis (Agnolucci and Drummond, 2014). Options for structural reform of the EU ETS to attempt to overcome these issues were recently agreed, and are discussed in Section 4.2.1.

No other explicit carbon pricing instruments exist at the EU level, although some sporadic instruments exist in some Member States[10]. However, the Energy Taxation Directive (ETD) (Directive 2003/96/EC) acts to place minimum taxation values on all energy products, including electricity - although fuels used to produce electricity are exempt, as these are covered by the EU ETS. Products used for domestic heating and in agriculture may also be exempt, along with products used for heating and the operation of stationary motors in energy-intensive industry, and fuel for international aviation (both of which are covered by the EU ETS) and international shipping (Drummond, 2013). For products and sectors subject to these minima, rates are set on a volume basis, and are not equalised across products in terms of either energy or carbon content. For example, the implicit carbon price for the minimum levy on coal is around €1.1/tCO_2, whereas for petrol, this value is €145/tCO_2 (European Commission, 2011a). However, it must be made clear that such fuel taxes serve a number of purposes, and internalising the external costs of CO_2 emissions is only one among them. Additionally, many Member States levy rates substantially higher than the minimum on different products for different purposes, often exacerbating market distortions (see Sections 0 and 3.2.3, below).

Numerous modelling studies have sought to determine the shadow marginal (or explicit) carbon price produced with (or required for) significant decarbonisation of the energy system by 2050. Knopf *et al* (2013) applies European decarbonisation scenarios[11] to thirteen different models[12], with resulting marginal carbon prices ranging from €61-169t/CO_2 in 2030 (with a median of €76/tCO_2), and €240-1127/tCO_2 in 2050 (with a median of €521/tCO_2) (Drummond, 2015). The modelling work undertaken as part of the CECILIA2050 project produce values that fall largely within this range. Solano and Drummond (2014) project a value of €80/tCO_2 by 2030 and €220 by 2050, whilst Meyer *et al* (2014) project values of €230 – 460/tCO_2 by 2050. Additionally, the modelling work undertaken by the ER2050 projects a 2050 value of €265/tCO_2 (European Commission, 2011b).

The choice of instrument to achieve such prices is largely secondary from a technical

[10] e.g. the CRC Energy Efficiency Scheme in the UK.

[11] All scenarios reach an 80% reduction in CO_2 emissions below 1990, but with differences in international co-operation, trade and other linkages. See Knopf *et al* (2013) for more detail.

[12] Partial equilibrium energy system, macroeconomic computable general equilibrium (CGE) and growth models, with different geographic and temporal resolutions, and sectoral definition and coverage. See Knopf *et al* (2013) for more details.

perspective (although theoretical arguments would favour the use of a taxation approach, rather than an emissions trading system). Whilst in the long-term theoretical arguments may drive decision making, in the short-term decisions are constrained by the design of existing climate policy landscape and aspects of feasibility (particularly political acceptability and legal compatibility).

3.1.2 Complete the EU-Wide Electricity Market Reform and System Integration

Currently, electricity generated and available in European markets is dispatched according to the 'merit order', which is set by the marginal generation costs of each generator. For fossil fuel generators the marginal cost represents fuel costs (including a carbon price), whilst for renewable generators, this cost is zero (or near zero). As such, renewables enter first in the merit order and are (generally) dispatched first, with the generators of increasing marginal cost (first nuclear, and then fossil fuel plants), dispatched according to demand. The wholesale electricity price is set by the marginal costs of the marginal generator, meaning that at times of high demand prices are higher, with generators lower in the merit order receiving increasing revenue (at the differential between their marginal costs, and the wholesale price). With increasing penetration of renewables, fossil fuel plants are increasingly displaced, resulting in lower average wholesale prices are produced. This means that more expensive fossil fuel plants are increasingly priced out of the market, operating fewer hours than anticipated, and thus unable to generate the expected revenue, leading to a 'missing money' problem. This dynamic also reduces revenue to renewable generators, and in the absence of dedicated support mechanisms, renders them also unable to generate sufficient revenue to cover non-marginal fixed costs (Drummond, 2015). As such, as the share of renewables in electricity generation increases, investment in new generation capacity (of any description) is no longer incentivised by the market, and the risk of creating stranded assets grows. Indeed, negative pricing on the wholesale market[13] has begun to occur in some Member States (Agnolucci and Drummond, 2014). Around half of all Member States have introduced, or have proposed the introduction of, capacity mechanisms (discussed under Section 4.4.1 to ensure presence of and investment in adequate capacity in response to fears that the energy-only market will increasingly fail to provide such incentive (Platts, 2015). Therefore, a new electricity market design is required.

The establishment of a single, EU-wide integrated redesigned electricity market holds enormous potential for creating more efficiency, stability and resilience in the power sector, and offers more options to balance fluctuations in power generation across Member States than are currently available, potentially reducing the need for parallel instruments (e.g.

[13] Negative pricing occurs when inflexible generation (such as nuclear and coal generation), submit negatively priced bids to allow them to remain generating in the presence of significant renewable generation and low demand, as the process of shutting down and restarting such plants is often more expensive.

capacity mechanisms). However, this requires a fully integrated physical transmission and distribution network.

The establishment of a single, integrated and liberalised EU electricity market and network has long been a policy objective of the EU. A key policy package that attempts to realise this objective is the 'Third Energy Package', introduced in 2009, and largely 'operationalised' through Directive 2003/54/EC), which requires:

- **'Unbundling' of generators, suppliers and transmission system operators (TSOs)**. This principally involves the separation of network activities from generation and supply activities, and the separation of generation and supply accounts. The purpose is to ensure competition in the market, that activities operate according to commercial principles, and access to transmission infrastructure is non-discriminatory (Agnolucci and Drummond, 2014). Around 96 of the approximately 100 TSOs are compliant with the 'unbundling' requirements, although full implantation is still required across all Member States (European Commission, 2014c).
- **'Open and fair' retail markets**. Whilst 'unbundling' of interests produces competition, allowing for a competitive market price for electricity to emerge, retail markets must be able to respond effectively and pass a 'fair' price, but one that reflects the cost of generation and transmission, through to consumers. The establishment of independent regulators is required to ensure this. The independent Agency for the Co-operation of Energy Regulators (ACER) was also established to ensure cross-border co-operation between such regulators. However, full independence and suitable allocation of legal competence is not fully in place for regulators in all Member States (European Commission, 2014c). Additionally, many Member States still apply regulated, rather than market-based retail prices (covering 51% of residential consumers in 2012) (European Commission, 2014d).
- **Deployment of smart meters**. Smart meters must be deployed to at least 80% of electricity consumers in the EU by 2020, for cases in which such deployment is considered positive on a cost-benefit analysis. This was the case for around two-thirds of electricity consumers in the EU. At least 16 Member States will proceed (or already have) with a large-scale rollout of smart meters by 2020 or earlier. Currently, five Member States have no legal framework for deployment and/or regulating specific matters, such as timeline of the rollout, or setting technical specifications for the meters. In total, around 72% of electricity consumers are likely to use a smart meter by 2020 (European Commission, 2014d). Commission Recommendation 2012/148/EU, on preparations for the roll-out of smart metering systems, provides recommended minimum common technical requirements for electricity smart metering systems[14]. However, at present only 8

[14] Including (a) Provide 'real-time' readings and visualised consumption data directly to the consumer (using a standardised interface, (b) allow remote reading by the operator, and frequently enough to be used for network planning, (c) provide two-way communication between the smart metering system and external networks for maintenance and control of the metering system, (d) support advanced tariff systems through the use of time-of-use registers and remote tariff control, (e) provide the option import/export and reactive metering, which

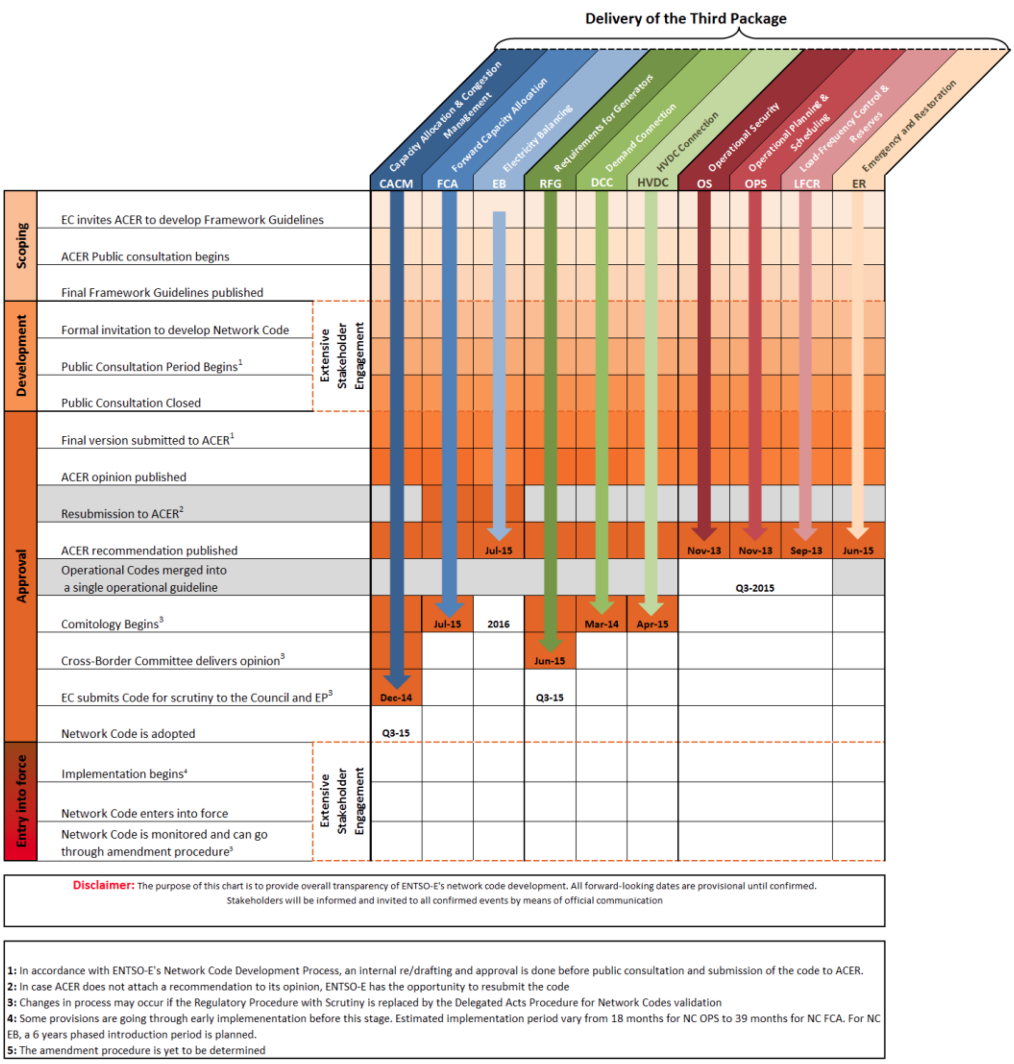
Member States are in compliance with these voluntary standards (European Commission, 2014d).

- **Development 'Ten Year Network Development Plan' (TYNDP) and 'network codes'.** The European Network of Transmission System Operators (ENTSO-E) was established by the Third Energy Package with various objectives, including the production of biennial 'Ten-Year National Development Plans' (TYNDPs), to identify gaps and priority requirements for EU transmission infrastructure that require attention (further discussed below), and the development of ten 'network codes' for governing various aspects of the electricity network and market (required by Regulation 714/2009). These may be broadly categorised into 'Connection Codes' (including *Requirements for Generators*, *Demand Connection and HVDC Connections*), 'Operational Codes' (including *Operational Security, Operational Planning and Scheduling,* and *Load Frequency Control and Reserves*), and 'Market Codes' (*Capacity Allocation and Congestion Management*, *Forward Capacity Allocation* and *Electricity Balancing*). A final 'stand-alone' code concerns *Emergency and Restoration*[15] Figure 3 illustrates the current development status of each network code. As is clear, no network codes have yet entered the implementation stage.

may be activated and deactivated in accordance with the wishes and needs of the consumer (f) allow remote on/off control of the supply and/or flow of power limitation, and (g) provide secure data communications and allow for fraud detection and prevention.

[15] See http://networkcodes.entsoe.eu/ for more information regarding each of the codes.

Figure 3 - Network Codes Implementation Status - July 2015 (Source: ENTSO-E, 2015)



The Renewable Energy Directive (discussed further under Section 3.2.1) requires Member States to 'take appropriate steps to develop transmission and grid infrastructure…including interconnection between Member States and third countries', in order to accommodate the increase in intermittent and distributed renewable generation (Drummond, 2013). A target set in 2002 by the European Commission, which required interconnector capacity in each Member State to equal 10% of domestic generation capacity by 2005, supports this (Agnolucci and Drummond, 2014). However, Zane et al (2012) find that of the EU27, only three countries exhibit a grid infrastructure and management approach (e.g. grid expansion plans, rules governing sharing and bearing of costs), favourable to RES-E integration (Finland, Ireland and Portugal), with nine providing negative conditions (including the UK, France, Poland and the Czech Republic), with the remaining fifteen found as neutral. A lack of suitable grid infrastructure is cited as a barrier to RES-E deployment in ten Member States. At least eleven Member States were found to not consider the requirements of RES-E sufficiently in long-term development plans (Agnolucci and Drummond, 2014; Zane et al, 2012). Additionally, by the end of 2014, twelve Member States had still failed to reach the

10% interconnection target[16] (European Commission, 2015k). Key reasons for such circumstances are discussed below.

The 2014 TYNDP, introduced above, estimates that an additional 44,000km of transmission capacity likely to be required by 2030, in addition to the approximate 300,000km already in existence (Eurelectric, 2013). This equals a required annual increase of 1% per year (ENTSOE, 2014). However, such values do not consider existing transmission lines that will require replacement. The average age of the European high-voltage transmission system is 30-40 years, against a typical lifetime of 30-50 years (Battaglini *et al*, 2012), meaning a high proportion of existing capacity must also be replaced by 2030 (Drummond, 2015). In addition, the TYNDP projects that interconnector capacity should on average double by 2030, although there are large discrepancies between regions, with some requiring much greater capacity increases. Connection between the Iberian Peninsula and mainland Europe may require up to a tenfold increase, with interconnection between the three Baltic States (Estonia, Latvia and Lithuania) and the rest of the EU, trebling. Interconnection capacity between Ireland, the UK and continental Europe is also projected to require doubling, if not trebling (Drummond, 2015; ENTSOE, 2014).

However, three key hurdles have inhibited, and are likely to continue to inhibit, such developments. The first surrounds **authorisation, planning and procedural issues**, which vary significantly between Member States (Battaglini *et al*, 2012). For example, the complexity and unpredictability of procedures and decision making at local authority level (several of which such infrastructure must pass through), and opposition by local inhabitants, means that permission processes to construct long-distance, cross border interconnectors may take up to 20 years in some cases (Battaglini *et al*, 2012), with an average of 10-13 years for most transmission infrastructure projects (European Commission 2015f). To combat such issues, permit applications must be 'one-stop-shops' (i.e. a single competent authority) for cross-border transmission lines categorised as Projects of Common Interest (PCI)[17], as mandated by the Regulation on Guidelines for Trans-European Energy Infrastructure (TEN-E Regulation) (347/2013). The TEN-E Regulation also places a binding time limit of 3.5 years for permit granting for PCI projects, along with a requirements for 'enhanced public participation. Whilst TEN-E regulation requirements were not achieved by November 2013 (as required), enforcement action by the Commission means all Member States should now be in compliance (European Commission, 2015d).

The second key hurdle is that of **financing**. Transmission and distribution infrastructure is currently financed largely through tariffs on consumer bills, usually defined by national regulatory agencies to reflect capital costs, depreciation and operational costs of an

[16] Ireland, Italy, Romania, Portugal, Estonia, Latvia, Lithuania, the UK, Spain, Poland, Cyprus and Malta.

[17] Projects of Common Interest (PCIs) are those that (a) have a significant impact on the energy markets of at least two EU countries such as by contributing to the integration of their networks, (b) increase competition in energy markets by offering alternatives to consumers, (c) enhance the EU's security of supply by allowing countries to receive energy from a greater number of sources, and (d) contribute towards the EU's energy and climate goals, for example by facilitating the integration of renewable energy into the grid. PCIs are selected based on the TYNDP, and are updated every 2 years (European Commission, 2015q).

'efficient' Transmission System Operator (TSO). However, the magnitude of the investment required across Member States in the coming years means that continuing such an approach is likely to be unsustainable. This may be particularly the case for interconnectors, which are generally built on the basis of 'user commitments', following agreement between TSOs and regulators in each jurisdiction. Usually, countries that are net importers ultimately pay those that are net exporters via a centrally administered fund, with costs recovered from consumers via tariffs described above. However, producing such agreements becomes increasingly difficult as the benefits of interconnectors become more regional than national, or where a link between two countries primarily benefits a third country[18] (Drummond, 2015). The final hurdle, linked to the above issues, is political. For example, Member States are unlikely to be willing to invest in new infrastructure, particularly interconnectors, if the beneficiaries lay primarily within another Member State. Interconnections between France and Spain have been reportedly delayed due to fears that low marginal cost renewable generation from Spain would undermine nuclear generators in France – a highly political issue (Drummond, 2015).

3.1.3 Make Sound Infrastructure Choices Despite Technological Uncertainty

Whether for electricity generation, transport or residential heating (amongst others), there is much uncertainty surrounding what exactly the low-carbon economy and society will look like, and which technologies will ultimately be made available and deployed to deliver it cost-effectively. For example, electricity may be generated largely by centralised or decentralised renewables, with CCS playing perhaps a significant role or none at all. In transport, the combination of electricity and hydrogen, or mode switching, that will eventually produce the requisite decarbonisation requirements is unclear. Additionally, the cost-effective and appropriate solutions may vary across both space (i.e. Member States) and time (i.e. one technology may become initially dominant, with another then superseding it).

Whilst market dynamics (with targeted policy intervention) may hold a significant influence on which competing solutions are ultimately implemented, core choices made by governments of all levels define the parameters within which markets may operate, and may create path dependency. Some such choices must be made to enable substantial decarbonisation to occur in the timeframe required, however these choices must enable such decarbonisation in a cost efficient manner, and minimise the risk of creating stranded assets.

Various Directives require Member States to construct plans for how they plan to deliver the obligations laid out by accompanying provisions, which often necessitates such long-term decisions. For example, the Renewable Energy Directive requires Member States to adopt

[18] The ability to finance International transmission lines through the 'merchant interconnector' model, in which operators may profit from the difference in electricity prices between countries, will also reduce over time as the single electricity market becomes established, producing price convergence (UK Parliament, 2011).

National Renewable Energy Action Plans (NREAPs)[19], whilst the Energy Efficiency Directive (discussed under Section 3.2.3) requires the implementation of a National Energy Efficiency Action Plan (NEEAP)[20]. Although, such plans only require detailing up to the time horizon for which obligations are present (often 2020), and compliance with required content and submission deadlines for such plans is often low (Drummond, 2013). Other key examples include the Alternative Fuels Directive (discussed under Section 0), and the TYNDP (discussed under Section 3.1.2, above). At Member State and local level, spatial planning regimes are also pivotal in facilitating or preventing the required infrastructure.

3.1.4 Provide Finance and Mobilise the Investments Necessary for a Low-Carbon Economy

The low-carbon transition will require not only the mobilisation of new finance, but also a substantial shift of existing finance invested in high carbon assets, across all sectors and from all sources. Finance and investments may come from governments or other public institutions (such as state-owned enterprises, public financial institutions or other investment vehicles), institutional investors such as pension funds and sovereign wealth funds, commercial banks and capital markets, private (non-financial) businesses, and individuals. The resources these sources collectively hold are well beyond the investments required to successfully achieve the low-carbon transition. However, various barriers stand in the way to unlocking the flow of finance required. Principal examples include (OECD, 2015):

- **Relative attractiveness of high- and low-carbon investments**. High-carbon investments and assets, in the absence of a substantive carbon price (and in the presence of various market distortions, such as fossil fuel subsidies), are often lower cost and/or provide a greater return than equivalent low-carbon assets (e.g. diesel vehicles over electric, or gas-fired power plants over offshore wind).
- **Reduced government budgets**. Since the 2008 financial crisis, governments (local, national and supranational) have fewer resources to allocate for different purposes, including investment in infrastructure and encouraging the development and deployment of both new and (relatively) mature low-carbon technologies
- **Financial market and investor requirements and incentives**. Some argue that the international 'Basel III' accords, which were introduced in the wake of the financial crisis and aim at improving and harmonising supervision and regulation of banks (including strengthening the stringency of capital adequacy and liquidity requirements), are having unintended consequences on the ability of private financial actors to invest in long-term,

[19] Must include individual renewable energy targets for the electricity, heating and cooling and transport sectors; the planned mix of different renewables technologies; policy measures to achieve national targets including co-operation between local, regional, and national authorities; planned statistical transfers and/or joint projects with other countries, national policies to develop biomass resources; and measures to ensure that biofuels use to meet renewable energy targets are in compliance with sustainability criteria.

[20] Must be submitted every 3 years, and include information on how each of the provisions in the EED is to be achieved. A guidance template was published by the Commission in 2013 (https://ec.europa.eu/energy/sites/ener/files/documents/20131106_swd_guidance_neeaps.pdf).

low-carbon infrastructure (NCE, 2015). Similar arguments are presented for 'Solvency II', which introduces more stringent quantitative (solvency ratios) and qualitative (risk management and supervision) requirements for EU insurance companies (implemented by Directive 2009/138/EC). It is argued that these requirements have the effect of inducing insurers to reallocate investments away from equity and towards more highly rated securities. The impact on direct infrastructure may also be negative, as the amount insurers may invest in non-listed assets is no longer limited.

- **Information failures.** A lack of clarity on fiduciary duty concerning environmental, social and governance issues**,** and the broad lack of disclosure and risk assessments concerning both emissions and high-carbon assets (including fossil fuel assets) that may form substantial liabilities or become stranded assets in the long term, fails to provide investors and finance providers with the appropriate information to adequately assess risk profiles.
- **Low long-term confidence**. Confused and abruptly changing political commitments, policy frameworks and instruments deter private investment (in both deployment and development in new technologies), and raise the cost of capital.

Actions to reduce and overcome these barriers must be encouraged and introduced as soon as possible in order to establish the required infrastructure, prevent continued investment in assets that may be at increasing risk of becoming stranded as the requirement for reduced GHG emissions tightens over time.

3.1.5 Encourage Low-Carbon Lifestyles

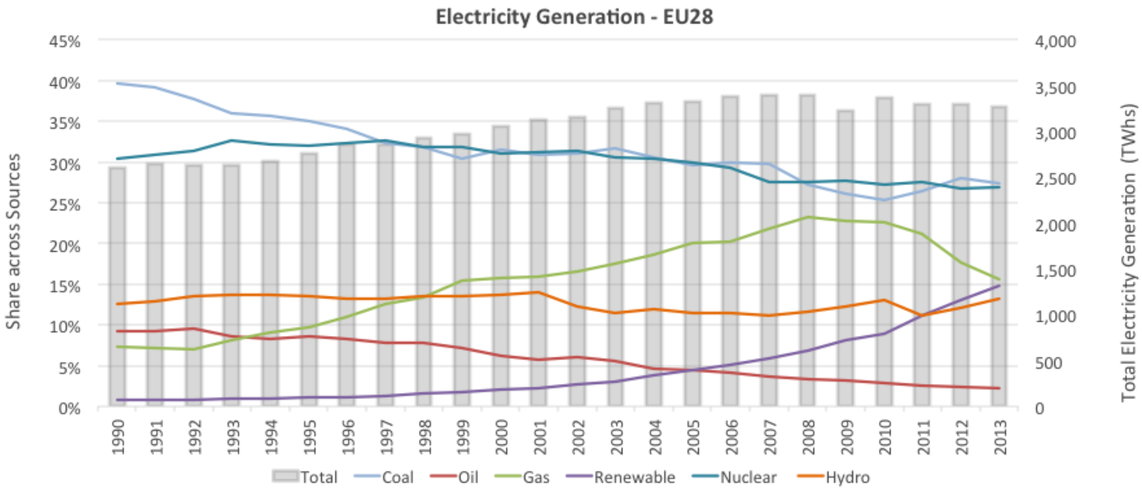
For efforts to achieve the low-carbon transition to be effective and feasible, individual citizens must become involved in implementing low-carbon lifestyles in their function as consumers, as investors, or as members of local communities. To do so, citizens must be motivated to make appropriate choices, be informed as to what these choices are, and be empowered to make them. Additionally, as voters, they need to be convinced to support, or at least to accept climate policy measures of sufficient ambition to meet increasingly demanding GHG reduction requirements. From a policy design perspective, this requires climate policies which create clear and demonstrable social benefits, and which – to the greatest extent possible – address any negative distributional impacts of climate policies, and cater for the needs of particularly vulnerable groups.

3.2 Sectoral 'Challenges' - Description and Status Quo

3.2.1 'Fully' Decarbonise the Power Sector

The power sector is the largest contributor to EU CO_2 emissions, and as discussed in Section 2.2.1, must lead the way in producing abatement by decreasing its emissions between 2012 and 2030 by half, and achieving almost total decarbonisation by 2050 (see Figure 1). As discussed under the various 'challenges' below, a key strategy for decarbonisation is the electrification of energy service demands across various end-use sectors (particularly in transport and buildings). As such, it is essential that CO_2 emissions are not simply shifted upstream. Figure 4 illustrates the evolution of the profile of power generation across the EU 28 between 1990 and 2013.

Figure 4 - Gross Electricity Generation - Total and by Source (including autoproduction) (Data Source: Eurostat)



As is clear from Figure 4, the profile of the EU's power sector has changed significantly since 1990[21]. By 2013, coal and nuclear accounted for around 27% of generation each, followed by natural gas and renewables at around 15% each, hydro at around 13%, and generation from oil at around 2%. The average CO_2 intensity of generation in 2012 was around 370gCO_2/kWh (down from around 550gCO_2/kWh in 1990 and 420gCO_2/kWh in 2000).

Two principal climate policy instruments currently exist to tackle CO_2 emissions from the power sector. The first is the EU ETS, described in Section 3.1.1, which acts to place a cap on emissions from the covered sectors, and a carbon price on fossil fuel generation. The second is the Renewable Energy Directive (RED) (Directive 2009/28/EC), which places legally binding targets on Member States for gross final energy consumption sourced from renewables by 2020 (operationalising the 20% EU-wide target for 2020[22]). All Member States (excluding Latvia) currently offer support mechanisms and incentives of varied design (e.g. feed-in tariffs, feed-in premiums, portfolio obligations, etc.) for the deployment of different types

[21] See Agnolucci and Drummond (2014) for a detailed description of this change, and the drivers behind it.

[22] The average of these targets is 20%. Each Member State target takes into account its share of renewable energy in 2005, modulated to reflect efforts made in preceding years. 5.5% is then added to this modulated value for each Member State. The remaining effort required was then weighted according to each country's GDP and population (Drummond, 2013a).

and sizes of renewable electricity installations, in order to achieve these regulatory requirements. The RED also requires Member States to, *inter alia*:

- Ensure a **certification scheme for installers of microgeneration technologies** is established, with a list of certified installers made public (and mutually recognised across Member States).
- Ensure the division of **responsibility between national, regional and local authorities is clear and transparent**, with **administrative processes streamlined**.
- Ensure **guaranteed access to the grid** for energy produced from renewables, with generation from renewable sources given **priority for dispatch**.

As discussed in Section 2.1.1, whilst the EU ETS has thus far produced relatively moderate, temporary abatement through 'fuel switching', the principal climate policy driver behind the increase in renewables illustrated in Figure 4, and associated reduction in CO_2 intensity, are dedicated renewable support mechanisms largely introduced to satisfy the requirements of the RED (and its predecessor, the Renewable Electricity Directive). However, poor design of support mechanisms in some Member States (including in some cases, retroactive changes to support provided), along with under- and poor-quality implementation of other RED provisions have acted as key barriers to further and more rapid deployment of renewable electricity. For example, most Member States still require multiple permissions to be granted, with only a few providing 'one-stop-shops' (European Commission, 2013). Additionally, most Member States have issues with ineffective or inefficient administrative procedures, and with guaranteeing grid connections (Agnolucci and Drummond, 2014). The latter issue is, in part, due to issues with the deployment of grid infrastructure, discussed in Section 3.1.2, above. Issues with spatial planning and public acceptability are also substantial in some Member States (Agnolucci and Drummond, 2014).

As also discussed in Section 2.1.1, the Large Combustion Plant Directive (LCPD) (Directive 2001/80/EC), which aims to reduce emissions of acidifying pollutants, particles and ozone precursors from large combustion plants with a rated thermal input greater than 50MW, has also likely had some impact in advancing the closure of aging coal-fired power plants. Whilst not a driver for abatement thus far, the CCS Directive (Directive 2009/31/EC), requires all new thermal combustion plants to be CCS 'capture ready', if suitable storage sites are available, transport facilities are technically an economically feasible, and it is technically and economically feasible to retrofit for CO_2 capture (Articles 32 and 33).

In order to reduce CO_2 emissions from the power sector by approximately half between 2012 and 2030, CO_2 intensity of generation must reduce to around 150gCO_2/kWh by 2030, alongside relatively rapid increases in electricity demand expected over the coming years (despite the recent plateau illustrated in Figure 4, as a result of increasing electrification of transport and heating). In the long-term, this must reduce to a maximum of around 10gCO_2/kWh (by 2050) (Drummond, 2015). Whilst the particular configuration of generation (and generating capacity) to achieve this is not clear, such levels are only feasible if the generation mix is dominated by zero-carbon power generation (including storage), with very limited fossil generation as back-up. It is thus certain that renewables must continue to increase dramatically (potentially complemented by and increase in nuclear[23] and fossil fuel with carbon capture and storage (CCS) in the medium- to long-term), whilst conventional fossil fuel generation must rapidly reduce. In particular, the construction of new unabated coal-fired installations – the most CO_2-intensive fossil fuel generating source – must be avoided, to reduce the risk of creating high-cost stranded assets (coal-fired power stations have a typical lifespan of around 40 years). Other aspects, such as a suitable electricity market and adequate transmission infrastructure (discussed in Section 3.1.2), are also required.

3.2.2 Facilitate Low-Carbon Transport

As the second largest contributor to EU CO_2 emissions in 2012 (Figure 1), facilitating a substantial shift to low-carbon transport is crucial. Reducing CO_2 emissions from road transport is a particular priority, as these modes alone account for ~95% of all domestic transport-related CO_2 emissions in the EU (and around 72% if international transport CO_2 emissions are considered) (European Environment Agency, 2015b).

As mentioned in Section 2.1.1, the existing policy landscape for the transport sector is uneven; passenger cars are subject to various instruments, whilst the international shipping sector is subject to none, with other modes covered to different degrees in between. The principal instrument acting on passenger cars is fleet-average CO_2 intensity regulations (implemented by Regulations 443/2009 and 333/2014). Manufacturers are required to ensure that by 2015, the average of new vehicles sold must not exceed a CO_2 intensity of 130gCO_2/km across their fleet, with this target reducing to 95gCO_2/km by 2021. The average CO_2 intensity of new passenger cars sold in 2014 across the EU was 123.4gCO_2, indicating the 2015 target has been achieved early (European Environment Agency, 2015c). Light Goods Vehicles (LGVs) are also subject to such fleet-average regulations (implemented by Regulations 510/2011 and 253/2014), with corresponding targets of 175gCO_2/km by 2017, and 147gCO_2/km by 2020. The average CO_2 intensity of new LGVs sold in 2014 across the EU was 169.2gCO_2, again indicating early achievement (European Environment Agency, 2015c). In order to incentivise the development and deployment of ultra-low emission vehicles (ULEVs, with a CO_2 intensity below 50gCO_2/km), 'super credits' are available to manufacturers of both passenger cars and LGVs[24].

Vehicle testing to determine compliance with these regulations is currently conducted using the New European Driving Cycle (NEDC) methodology. The NEDC does not take into account various factors that influence CO_2 emissions (e.g. vehicle weight) (ICCT, 2014), and has resulted in an increasing differential between 'laboratory' and 'real world' CO_2 intensity

[23] However, the deployment of nuclear generation is usually a political choice, with relatively few EU Member States currently in favour of constructing substantial (if any) new capacity (Solano and Drummond, 2014).

[24] For cars, each ULEV counts as the equivalent of 3.5 vehicles in 2013, 2.5 in 2014, 1.5 in 2015 and 1 from 2016 to 2019. However, this increases again to 2 vehicles in 2020, 1.67 in 2021, 1.33 in 2022 and 1 in 2023 (although from 2020 onwards, super credits may only be used to achieve a maximum of 7.5gCO2.km towards compliance.. For LGVs, these values are 3.5 in 2014 and 2015, 2.5 in 2016, 1.5 in 2017 and 1 from 2018 onwards.

(Nijland *et al*, 2012). To counter this, it was agreed in March 2014 that the Worldwide harmonised Light vehicles Test Procedure (WLTP), with a design improved over the NEDC, will adopted in the coming years.

Passenger cars are also subject to the Car Labelling Directive (Directive 1999/94/EC), which requires information relating to the fuel economy and CO_2 intensity of passenger cars to be displayed at the point of sale for all new passenger cars sold or leased. Whilst minimum information requirements are mandated, specific designs vary by Member State. However, evidence suggests that such labelling has had little if any influence on consumer purchase decisions, due to a combination of low awareness of the label, poor understanding of the information provided, and a relatively low importance placed on environmental factors by consumers when purchasing a vehicle (Drummond, 2013a).

Although not an EU level instrument, another key policy factor that directly seeks to influence the vehicle purchase choices is national registration and circulation taxes[25]. 21 Member States currently levy registration taxes passenger cars (with very significant variations in value). Only 6 subject HGVs to registration taxes[26] (and even then exemptions or reductions often apply[27]). 14 Member States consider CO_2 emissions when setting registration taxes on passenger vehicles, with 6 holding CO_2 as one of two parameters (with the other often vehicle value). None of the 6 Member States that apply registration taxes to HGVs considers CO_2 emissions as a parameter (van Essen *et al*, 2012). Circulation taxes apply to passenger cars in 24 Member States, whilst all apply circulation taxes for HGVs (although again, with significantly different values). CO_2 is considered a parameter for passenger cars in 18 Member States (and the sole parameter in 6), but not at all in setting rates for HGVs.

Three key instruments directly apply to road transport fuel. Principal among these is the ETD, discussed in Section 3.1.1, which applies minimum taxation levels on all road transport fuels. However, as illustrated by Figure 5, there is a significant disparity between actual rates levied, both between petrol and diesel (the two primary fuels), and between Member States.

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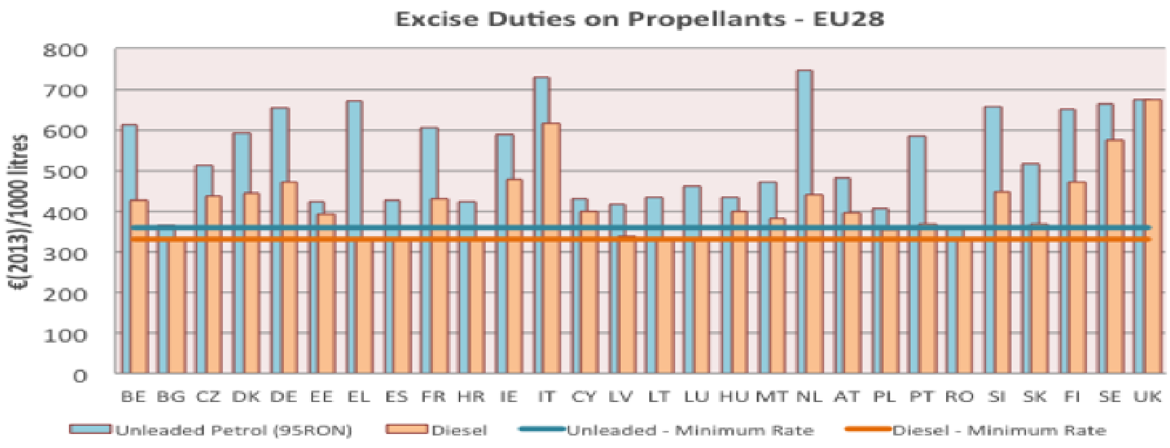
[25] Registration tax is an upfront tax levied on a vehicle when it is first purchased and registered. A circulation (or ownership) tax is a levy incurred by the owner to allow the use of a vehicle on public roads, the frequency of which (quarterly/biannual/annual) varies by Member State.

[26] Denmark, France, Greece, Italy, Malta and Romania

[27] e.g. Denmark (exemption for freight vehicles with GVW over 4,000 kg, and buses) and Malta (tax level for class N3 vehicles of one of the two most recent EURO classes equal to zero) (DG MOVE, 2012)

Figure 5 - Excise Rates on Petrol and Diesel in the EU28 (Source: DG TAXUD via Maca *et al* (2013))



Few Member States levy rates on the basis of CO_2 content. Additionally, such differentials produce varied price signals and lead to incidences of 'fuel tourism', particularly for long distance HGVs, which may plan refuelling stops to take advantage of price differentials, or even drive extra distance if cost-effective to do so, thus producing additional emissions (Maca *et al*, 2013).

The second two instruments are the RED and the Fuel Quality Directive (2009/30/EC). The former requires Member States to ensure that at least 10% of final energy consumption from all forms of transport is from renewable sources within their territory, by 2020. Although this target applies to all forms of transport, the use of biofuels in road transport fuels is likely to be the manner in which this target is achieved in most Member States (Drummond, 2013a). The latter instrument requires a 6% reduction in GHG intensity of road transport fuels on a lifecycle basis between 2010 and 2020. This is also likely to be achieved primarily through the use of biofuels (European Commission, 2015h)

At present, the rules surrounding company car taxation in many Member States often act to significantly dull the influence of climate policy (particularly market-based) instruments acting on passenger cars. The reasons behind this are further discussed in Section 4.4.2. However, the effects of such distortions are evident in the size and make up of the company car fleet. Around half of all new car purchases in the EU are company cars (Copenhagen Economics, 2010), and higher in some Member States (e.g. 70% in Germany (Federal Motor Transport Authority, 2013)). Since, in most cases, the fuel costs are covered by the employer and not by the driver, the incentive for purchasing a fuel-efficient car is reduced. As a result, the market is heavily skewed towards larger, more powerful and more expensive vehicles. For example in Germany, over 85% of 'high-end' vehicles are sold as company cars, with some luxury models exclusively registered as company vehicles (Federal Motor Transport Authority, 2013). Consequently, CO_2 intensity for company cars is, on average, higher than for private vehicles (Maca *et al*, 2013).

As discussed in Section 2.2.1, modelling suggests that CO_2 emissions from the transport sector should plateau until 2030, and then reduce to around a third of 2012 levels by 2050.

This reflects that transport emissions increased significantly between 1990 and 2007 (before slowly decreasing from 2008), as illustrated in Figure 1, and have yet to enter into a phase of more drastic reductions. As such, GHG emissions from transport were 20.5% higher in 2012 than 1990 emissions (European Environment Agency, 2015b). This increase was driven largely by increasing demand, which, *ceteris paribus*, is likely to continue to increase.

Decarbonisation in the transport sector must be driven by a combination of three factors; reducing transport demand, modal shift of passengers and freight to existing low- or lower-carbon modes, and decarbonising the fuel mix of existing high-carbon modes. Whilst (and because) the weighting between these three drivers is difficult to foresee *ex ante* (both at Member State and EU level), all options must be facilitated (Drummond, 2015). For the first and second, cities must allow for and deploy the infrastructure required to enable, for example, remote working, improving efficiency in existing transport capacities, and ensuring high capacity public and active transportation (e.g. walking and cycling), whilst regions and Member States must allow and deploy infrastructure for long-distance, high-speed rail infrastructure. For the third, a shift from fossil fuels to low- and ultra-low emission vehicles and fuel, particularly electricity and hydrogen, must be facilitated and encouraged. This includes planning for and putting in place enabling infrastructure, such as electric charging points and hydrogen fuelling stations and supply pipelines if, where and when required.

Regarding such infrastructure, the Alternative Fuels Directive (Directive 2014/94/EU) is a key existing policy instrument. Under the Directive, Member States are to develop national policy frameworks for the market development of alternative fuels and their infrastructure. Each Member State must ensure that the requisite number of publicly available electric recharging points is in place by 31st December 2020 to ensure that electric vehicles are able to circulate at least in urban and suburban agglomerations and other densely populated areas. Of Member States that choose to adopt hydrogen and fuel cell vehicles, an appropriate number of refuelling points must be available to ensure circulation of such vehicles within nationally determined networks (including cross-border links), by 31st December 2025. Member States have until September 2016 to transpose these requirements into national law (Drummond, 2015).

3.2.3 Tackle the Energy Consumption of the Housing Stock

As illustrated by Figure 1, direct CO_2 emissions from buildings account for around 16% of total CO_2 emissions from the EU28. The residential sector accounts for around 70% of this (European Environment Agency, 2015b), along with a quarter of total final energy consumption within the EU28 (with space and water heating accounting for the vast majority of both CO_2 emissions and energy demand). In 2012, the average energy intensity of the existing EU residential stock was 185 kWh/m^2 (Gynther *et al*, 2015). Reducing the energy consumption of the building stock is therefore an essential first step for reducing CO_2 emissions from the residential building stock (with a reduction in the CO_2-intensity of remaining demand also required). Due to the longevity of the residential building stock, the risk of high-energy and high-carbon lock-in is significant. As such, early action must be taken to prevent such lock-in from persisting. Additionally, due to the existing 'energy efficiency gap'[28], improving the energy efficiency of residential buildings may generate net savings, and reduce the cost implications of other, increasingly stringent climate policy measures on individual consumers (e.g. increasing carbon pricing, RES-E cost recovery).

Four key Directives currently attempt to tackle energy consumption in the residential sector (and buildings more broadly). The first is the Energy Performance of Buildings Directive (EPBD) (2002/91/EC), which contains two key provisions concerning the residential sector. The first is the requirements for building minimum energy performance standards (MEPS), including the requirement that by 31st December 2020, all new buildings must be classified as 'nearly zero-energy buildings' (NZEBs). An NZEB is defined as a building with a 'very high' energy performance, with the remaining energy demand covered 'very significantly' by renewable energy. Each Member State is required to submit their own interpretation of this definition considering national, regional and local conditions. Requirements for new residential buildings vary between 33 kWh/m^2/y (Croatia) and 95 kWh/m^2/y (Latvia), with the majority setting definitions at 45 kWh/m^2/y or 50 kWh/m^2/y. Additionally, few Member States explicitly require that any proportion of the remaining energy consumption must be supplied by renewable sources (Ecofys, 2014a). Moreover, existing MEPS in many Member States are already poorly enforced, with compliance often found to be relatively low (Pan and Garmiston, 2012). The second key provision is the requirement that any new building, or any building that is sold or rented to a new tenant must issue an Energy Performance Certificate (EPC), which contains information on the energy performance of the building, reference values (such as minimum requirements), recommendations for the cost-effective improvement of energy performance, and indications of where the owner or tenant may find more information to implement these recommendations (Drummond, 2013a). The evidence suggests that EPCs have produced little impact on energy consumption for various reasons, including (a) varied design across Member States, (b) the use of different calculation methodologies across Member States, which are not uniformly robust, (c) low rates of monitoring across all Member States, casting doubt on the level of compliance, and (d) the precedence of other factors in the decision to purchase or rent a property (Drummond, 2015).

The second key Directive is the Energy Efficiency Directive (EED) (Directive 2012/27/EU), which again contains two key provisions concerning the residential buildings sector. The first is the requirement for Energy Efficiency Obligation Schemes (EEOS) in all Member States, in which energy suppliers must achieve the equivalent of average annual cumulative savings of 1.5% of total sales, by volume, based on average total sales of the industry across the three-

[28] Defined as the 'wedge between the cost-minimising level of energy efficiency and the level actually realised' (Allcott and Greenstone, 2012). Wesselink *et al* (2010) estimate that if such cost-negative actions were taken up by the EU's residential sector, its energy consumption would reduce by around 10% (ignoring potential rebound effects).

year period leading up to the 1st January 2013[29]. The obligation period is from 1st January 2014 to 31st December 2020, and Member States have flexibility as to how and when the required savings are implemented over this period. Alternative measures may be implemented in place of an EEOS (including an 'Energy Efficiency National Fund' to support energy efficiency initiatives), as long as such instruments achieve equivalent energy savings (Drummond, 2015). At present, 17 Member States have, or plan to implement, an EEOS (often in combination with other instruments, although of these, 8 have major credibility issues, 6 have minor credibility issues, and only 2 have no issues[30]). Additionally, evidence suggests that planned monitoring, verification, control and compliance regimes are likely to be inadequate (Rosenow *et al*, 2015). The second key provision under the EED (or rather, group of provisions) requires various measures to encourage the introduction of voluntary energy efficiency measures and action by end-users. This includes the introduction of smart meters (linked to the Third Energy Package requirements, discussed under Section 3.1.2), the provision of accurate billing information (including information on average energy consumption for households of a similar profile (a 'nudging' instrument[31]) and information on how to receive a free energy audit where 'possible and useful'), and the establishment of qualification, accreditation and certification schemes for providers of energy services, audits and installers of energy-efficiency elements, in Member States where technical competence, objectivity and reliability is insufficient.

The third key Directive is the Ecodesign Directive (2009/125/EC), which applies minimum performance standards on a range of energy-using and energy-related products[32]. Although not exclusively, in-use energy consumption or efficiency is often subject to such minimum standards. Various products, including heating system components (such as boilers), white goods and other appliances are currently subject to Ecodesign requirements, which the evidence suggests have been effective in driving (often substantial) efficiency improvements (Drummond, 2013a). However, the evidence also suggests a non-compliance rate of around 10-20%, largely due to under-resourced monitoring and enforcement procedures (Drummond, 2013a). Additionally, there are documented differences in efficiency levels of up to 30% between products subject to test procedures, and those operating in the real world (Toulouse, 2014).

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[29] Sales volumes to installations covered by the EU ETS may be excluded, along with consumption in the transport sector. As such, energy consumption from buildings is the *de facto* target for this instrument across most Member States.

[30] The final Member State, Portugal, has an existing ESOS instrument in place but has not notified the Commission of their intention to use this for Article 7 compliance, and thus instrument credibility was not assessed by this study.

[31] **'**Nudge theory' is a strain of behavioural science that looks at how the target can be encouraged to implicitly comply with policy objectives. It focuses on non-price interventions that can be just as powerful as prices in changing consumer choices, and energy policy has been shown to be an area which can benefit from 'nudging' people in the right direction (Allcott and Mullainathan, 2010),

[32] Products that have an indirect impact on energy consumption, such as water-using devices, insulation materials and windows

The fourth and final key Directive is the Energy Labelling Directive (Directive 2010/30/EU), which requires suppliers placing on the market or putting into service any energy-related product subject to an implementing measure (most often those also subject to Ecodesign Directive) to supply a label and a fiche (table of information) with the product containing information relating to energy consumption and other resources, where relevant. Products must be labelled on a relative scale, usually ranging from A+++ to D[33] (Drummond, 2013a). Whilst assessment of the effectiveness of the Energy Labelling Directive are difficult to separate from that of parallel measures (particularly the Ecodesign Directive), it is unlikely that it has had any significant impact on overall market sizes, structure or product choices amongst consumers for the products covered (Ecofys, 2014b). Evidence suggests that the introduction of A 'plus' labels appears to have induced confusion and a feeling of diminishing returns amongst consumers, reducing its efficacy compared to the simpler A-G scale previously in place (LE and Ipsos, 2014; Heinzle and Wüstenhagen, 2012). Additionally, around 90% of appliances covered by implementing measures fall into the 'A' category, removing the ability of consumers to distinguish between products on the basis of energy efficiency (Heinzle & Wüstenhagen, 2012). Moreover, the level of compliance monitoring is low across Member States (Ecofys, 2014b).

As discussed in Section 3.1.1, domestic heating fuels may be exempt from taxation (except VAT) under the ETD, with carbon pricing only (commonly) levied on electricity via upstream application of the EU ETS. Issues such as the 'landlord-tenant dilemma'[34] and access to appropriate finance (Section 3.1.4), are key issues that must be overcome to satisfy this challenge.

As discussed in Section 2.2.1, direct CO_2 emissions from EU buildings must decrease by around 20% between 2012 and 2030, and to a third of 2012 levels by 2050, with a large majority of this reduction to be produced by the residential sector. This must occur despite a projected increase in residential floor space of around 25% by 2050 (IEA, 2012). This would mean a reduction in average energy intensity of the residential stock to under 150kWh/m^2 by 2030, and under 100kWh/m^2 by 2050 (from around 185kWh/m^2 in 2010) (Drummond, 2015). CO_2 intensity, however, must decrease at a more rapid rate. As such, whilst ensuring high energy efficiency and low emissions from new buildings is important, energy efficiency and CO_2 intensity of existing buildings must respectively increase and decrease substantially (including closure of the energy efficiency gap), through increasing both the efficiency of building envelopes (insulation, multi-glazed windows, air-sealing, the avoidance of thermal bridging and efficient thermal and lighting design, for example) and of energy-using products within the building (from boilers and air conditioning units and design, to lighting, white goods and consumer electronics) (Drummond, 2015). The remaining energy demand, particularly for space and water heating, must be increasingly satisfied by renewable or other

[33] A+ to A+++ ratings were introduced in the 2010 recast of the Directive. Prior to this, ratings were between A and G.

[34] Split incentives between the landlord (usually liable for capital cost of installation) and the tenant (usually liable for payment of energy bills).

low-carbon energy. Although it is once again not clear the extent to which different technologies are likely to contribute to this, electrification via heat pumps, in particular, is likely to play a significant role. However other technologies, such as solar thermal and biomass boilers, are also likely to contribute.

3.2.4 Stimulate Radical Low-Carbon Innovation in Industry

As illustrated by Figure 1, GHG emissions from industry must approximately halve between 2012 and 2030, and reach around a third of 2012 levels by 2050. Unlike other sectors, where clear options are already largely available to facilitate a low-carbon shift, options in the industrial sector to produce the level of abatement required are thus far lacking. GHG emissions in the industrial sector emanate both from energy production for self-consumption (e.g. the use of blast furnaces in the steel sector), and from chemical reactions from various industrial processes (additionally, as a substantial end-user of electricity produced by the power sector, indirect emissions are significant). Whilst some options are available to reduce current emission levels from each of these sources, 'breakthrough' technologies are need to achieve the level of abatement sought.

Most emissions from the industrial sector are covered by the EU ETS. Although as discussed in Section 3.1.1, above, the carbon price produced thus far has been too low for most of the ETS' operation to trigger energy-saving investments in industry. In addition, the majority of industrial installations receive most of their emission allowances allocated for free, to guard against the threat of carbon leakage. For the same reason, several Member States compensate electricity-intensive industries for the indirect carbon price they experience through purchased electricity. However, the presence of market failures associated with innovation means that pricing instruments such as the EU ETS, even if applied fully to the industrial sector (with appropriate carbon leakage measures), are unlikely to be sufficient. For example, it is virtually impossible to attribute all the benefits of innovation to the innovating firm – part of these benefits is bound to 'spill over', i.e. to diffuse beyond those that bore the cost of development, thereby reducing the incentive for an individual firm, for example, to invest in the first place when its competitors would also benefit (Jaffe *et al*, 2003; Lehmann, 2012).

As such, various other initiatives are in place to encourage low-carbon innovation in the industrial sector. The 'Innovation Union', and the various initiatives contained therein (discussed under Section 2.1.2.3, above), is the principal example. Additionally, the Strategic Energy Technology Plan (SET-Plan) aims to accelerate the development and deployment of low-carbon technologies, and includes the 'European Industrial Initiatives' (EIIs), which aims to bring together the EU, Member States, industry and researchers by pooling funding and resources to promote the development and uptake of key technologies. The Strategic Energy Technologies Information System (SETIS), led by the Joint Research Centre (JRC), plays a central role in delivering the SET-Plan. It undertakes independent research and publishes research reports and technology assessments and roadmaps. It also monitors the implementation of the SET-Plan using a range of Key Performance Indicators (KPIs) (European

Commission, 2015t). Work undertaken by SETIS feeds into 'Horizon2020', the EU's most recent framework programme for research and innovation, which provides funding for research into various societal challenges, into which low-carbon industrial innovation falls[35]. The JRC is also required by Article 13 of the Industrial Emissions Directive (Directive 2010/75/EU) to draw up, review and where necessary, update 'Best Available Technology' (BAT) reference documents, and organise an exchange of information between Member States, the industries concerned, non-governmental organisations promoting environmental protection, and the Commission.

3.2.5 Address non-CO_2 Greenhouse Gas Emissions, Particularly from Agriculture

Non-CO_2 emissions[36] currently account for around 20% of total GHG emissions from the EU, although as highlighted in Section 2.1.1, the majority of existing climate policy in the EU focuses on CO_2 emissions from the energy system. Non-CO_2 GHG emissions are rarely tackled in climate policy, or only very broadly (e.g. as part of the economy-wide targets under the ESD). An exception is the industry sector, which has non-CO_2 emissions covered by the EU ETS, and fluorinated gasses (F-gasses), man-made GHGs used primarily in industrial applications, covered by F-Gas Regulations (Regulation 842/2006)[37]

Agriculture accounts for around half of non-CO_2 GHG emissions in the EU (excluding LULUCF, discussed in Section 4.1.1.1), and thus around 10% of total EU GHG emissions (European Environment Agency, 2015b). As also described in Section 2.1.1, climate policy instruments that exist for the agriculture sector are at the Member State level, and are largely recent introductions, focus on information dissemination and R&D rather than direct emissions abatement, and are implemented on a voluntary basis. Although GHG emissions from the agriculture sector have decreased by over 20% since 1990 (particularly CH_4 and N_2O), this has been driven by a combination of provisions in instruments introduced for non-climate reasons.

The Common Agricultural Policy (CAP) is the primary instrument concerning the EU's agriculture sector, and is one of the oldest and most prominent policy instruments introduced by the EU (Kuik and Kalfagianni, 2013). Its broad objective is to manage the markets for agricultural products within the EU[38]. Whilst the CAP has undergone numerous

[35] Particularly 'Secure, Clean and Efficient Energy' and 'Climate Action, Environment, Resource Efficiency and Raw Materials'.
[36] Methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) and nitrous oxide (N_2O).
[37] F-gasses include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), which have global warming potentials (GWP) of up to 23,000 times that of CO_2. See Drummond (2013a) for a discussion of the instrument.
[38] More specifically, Article 39 of the TFEU states its primary objectives to be (a) to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of the factors of production, in particular labour, (b) thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of

revisions over the years, including increasing attention to environmental issues, a focus on actions to mitigate climate change first arose during the 2008 CAP 'Health Check', of which 'mastering new challenges from climate change' formed part of one of the three main issues addressed. Various measures were strengthened as a result, including R&D measures, innovation, 'cross compliance'[39], and advice on energy saving and emission mitigation approaches. However, no formal evaluation of the effects of these measures has yet been undertaken (Kuik and Kalfagianni, 2013). The Water Framework Directive (2000/60/EC) and its components (e.g. the Nitrates Directive (91/676/EEC))[40] are also key non-climate instruments that influence agricultural GHG emissions.

GHG emissions (principally CH_4) from the waste sector account for around 15% of total non-CO_2 GHG emissions in the EU (European Environment Agency, 2015b). A key instrument for tackling solid waste disposal (responsible for around two-thirds of waste sector GHG emissions) is the Landfill Directive (1999/31/EC). The principal provision of the Landfill Directive is the requirement for Member States to reduce biodegradable waste (the source of CH_4 emissions) entering landfill to 75% of 1995 levels by, reducing to 50% in 2009 and 25% in 2016. Most Member States have met or exceeded the 2009 target, with many achieving the 2016 target several years early (Drummond, 2013).

Whilst the focus of climate policy must remain with the energy system as the primary source of GHG (particularly CO_2) emissions, in the medium to long-term in particular, substantial reductions in agricultural emissions are likely to be required (along with reductions in non-CO_2 from other sources).

4 Options and Pathways for Policy Instrumentation and Institutions in the Short-Term

The options for instrument and institutional reform presented here consider the 'lessons learned' from the existing climate policy mix as described in Section 2.1.1, and take the 'status quo' described in the various challenges presented in Section 3 as the point of departure. All options presented respect the overarching targets and initiatives described in 2.1.2, along with the basic requirements for GHG reduction and climate policy described in

persons engaged in agriculture, (c) to stabilize markets, (d) to assure the availability of supplies, (e) to ensure that supplies reach consumers at reasonable prices.

[39]Cross-compliance is a mechanism that links direct payments to compliance by farmers with basic standards concerning the environment, food safety, animal and plant health and animal welfare, as well as the requirement of maintaining land in good agricultural and environmental condition (European Commission, 2015y).

[40] The WFD provides a framework of provisions and measures that aims to achieve 'good' quality ground and surface water by 2015. The Nitrates Directive aims at protecting water quality by preventing surface and groundwater pollution caused or induced by nitrates from agricultural sources through the promotion of good farming practices (Drummond, 2013a).

Section 2.2. The overarching effectiveness, cost efficiency and feasibility of the instrument mix is also considered, and summarised in Section 5.2.

The options presented assume that broad division of competences between the EU and Member States (e.g.. the principal of subsidiarity) is maintained in the short-term. It is also assumed that international co-operation in climate change mitigation improves against current levels, but does not achieve full alignment.

Although many of the options presented in this section are applicable regardless of specific developments under these broad assumptions, some options may be mutually exclusive if effectiveness, cost efficiency and feasibility is to be achieved. These options are presented as two distinct pathways of 'incentive-based' and 'technology-specific' options, and are described in Sections 4.2 and Section 4.3, respectively.

4.1 'Framework' Conditions, and Reform and Operation of Public Institutions

'Framework Conditions', presented in Section 4.1.1, refers largely to the overarching strategies, rules and requirements implemented at the EU level and applicable cross Member States. The 'Reform and Operation of Public Institutions', presented in Section 4.1.2, refers largely to the design, role and actions of public institutions at both EU level and within Member States.

4.1.1 'Framework' Conditions, Processes and Actions

4.1.1.1 Maximise Benefits of the 2030 Climate and Energy Package, 'Energy Union' and 'Innovation Union'

2030 Climate and Energy Package

As described in Section 2.1.2.1, the 2030 Climate and Energy Package only requires an overarching GHG emission target to be binding at individual Member State level, with renewable energy and energy efficiency targets 'binding' at EU level only. This is a departure from the 2020 Package, in which binding targets for GHG reduction and renewable energy are applicable to individual Member States. Whilst it is reasonable to suggest that three parallel, binding targets as per the 2020 Package may have been mutually reinforcing and encouraged Member States to actively pursue all three aspects, the current design means it must fall to other EU and Member State level measures to encourage aggregate achievement of the non-binding renewable energy and energy efficiency targets, alongside (and as contributors to) GHG targets. The options presented throughout Section 4 seek to achieve this end.

In October 2014, the European Council required the development of a policy proposal to include Land Use, Land Use Change and Forestry (LULUCF) in the 2030 Package. LULUCF activities include both emissions and removal of (principally) CO_2 from the atmosphere resulting from the use of soils (including agricultural soils, which unlike other agriculture sector emissions, are not included under the ESD), trees, plants, biomass and timber

(European Commission, 2015m). LULUCF activities are currently a net sink of CO_2, absorbing the equivalent of around 7% of GHG emissions emitted by the EU28 in 2012 (European Environment Agency, 2015b), although this is projected to decrease out to 2030 (Böttcher and Graichen, 2015). Historically, net emissions from LULUCF have been excluded from both EU and international level targets and agreements due to a lack of a robust, consistent measurement and accounting approach (Drummond, 2013a). Following the adoption of revised common measurement and accounting rules by the UNFCCC in 2011, a dedicated legal framework was introduced and implemented in 2013 by the EU in order to implement this harmonised methodology across Member States. The EU also requires Member States to prepare actions to increase removals and decrease emissions of GHGs from activities related to forestry and agriculture (Drummond, 2013a). In March 2015, the Commission opened a consultation on how the inclusion of LULUCF into the 2030 Package may be achieved[41]. Three key options were presented (Böttcher and Graichen, 2015):

- **Option 1** – 'LULUCF pillar' – Maintain non-CO_2 agriculture sector emissions in a potential future Effort Sharing Decision (ESD), and further develop a LULUCF sector policy approach separately.
- **Option 2** – 'Land use sector pillar' Merge the LULUCF and non-CO_2 agriculture sector emissions into one new independent pillar of the EU's climate policy
- **Option 3** – Include LULUCF in the ESD

It is likely that **Option 1**, **the introduction of a fully independent LULUCF sector policy approach, is the most desirable** - particularly from the perspective of overall environmental effectiveness. The reasons for this surround simply the nature of LULUCF emissions, and uncertainty of accounting. GHG emissions and removals from LULUCF activities are fundamentally different from fossil-based emissions and other sources of non-CO_2 emissions (including agriculture), for two key reasons. The first is the significant variability in LULUCF net emissions (for both natural and anthropogenic reasons). The capacity of land-based carbon sinks to remove CO_2 may vary substantially over seasons, and even daily (inter-annual fluctuations in some Member States are up to 60% (European Commission, 2012b)). The second is the long lead times for mitigation measures; most actions to increase sink capacity and absorption rates or reduce emissions take many years to take effect. Such phenomena make accurate accounting of LULUCF net emissions particularly difficult. Indeed, the average level of uncertainty associated with estimating net GHG emissions from LULUCF is sectors is around 35% across the EU (compared to 2-6% for fossil fuel-combusting sectors). Additionally, abatement measures, alongside exhibiting long lead times, are non-permanent, and may easily reversed (e.g. afforestation) (Client Earth, 2014).

As such, combining LULUCF with all other non-traded ESD sectors (Option 3), or with all other agricultural activities (Option 2) and thus allowing offsets between such sectors (or different types of activities within sectors), would likely undermine the credibility of the overall target and allow for the use of 'temporary' LULUCF measures to meet GHG targets that may be

[41] This consultation closed in June 2015, however at the time of writing, the results had not been published.

easily reversed, rather than more permanent systemic change in non-ETS energy system sectors. However in the longer-term (post-2030), once substantial decarbonisation has taken place in other sectors and as LULUCF accounting approaches have improved (with uncertainties reduced), broader inclusion may become more desirable.

Energy Union

At the time of writing, the proposed Energy Union remains largely a conceptual idea. Various options exist to maximise the potential for this initiative to drive the decarbonisation agenda. Two broad potential options are discussed here. The first is the **explicit reframing of the Energy Union to the 'Energy and Climate Union'**. This may further embed the prominence of the decarbonisation imperative and emphasise dimension '(d)' of the existing concept (decarbonising the economy, discussed in Section 2.1.2.2). Additionally, this would allow for the Vice President for Energy Union to explicitly take on a 'climate' role, contributing the 'mainstreaming' of climate mitigation (in particular) across broader EU activities and policy making. Whether this is a more or less desirable option would depend on whether a single Commissioner for climate and energy remains, or whether such competencies are divided (such issues are discussed under Section 4.1.2.1, below). However, the political feasibility of such a 'rebrand' may be questioned, and the extent of benefits in addition to the climate-related aspects of the existing concept of the Energy Union (and associated KAPs), must be further investigated before such an option is proposed.

The second option is **leveraging the Energy Union concept and processes to encourage and incentivise the deployment of renewables and energy efficiency measures, to compensate for the lack of binding Member State level targets and direct incentives in the 2030 Climate and Energy Package**. For example, non-binding benchmark targets for renewables deployment and energy efficiency improvement could be calculated for each EU region (perhaps using a methodology akin to that used for calculation of the Member State 2020 targets for renewables, but aggregated to regional levels[42]). Additional funding (such as hypothecated EU ETS revenue, discussed under Section 4.2.1) or other benefits may be provided to incentivise achievement (and/or overachievement) of these benchmark targets (Held *et al*, 2015).

A regional approach such as this may have several advantages against a situation of no such benchmarks and incentives (and even against a Member State level approach), as it encourages co-operation between Member States. This may help to reduce or remove existing barriers to harmonisation efforts, particularly concerning electricity transmission infrastructure and electricity markets (discussed further under Section 4.1.1.3, below). Long-term and co-ordinated planning is incentivised to prevent excessive investment in

[42] For renewables each Member State target takes into account its share of renewable energy in 2005, modulated to reflect efforts made in preceding years. 5.5% is then added to this modulated value for each Member State. The remaining effort required was then weighted according to each country's GDP and population, in order to produce nationally appropriate target efforts to achieve the overarching goal (Drummond, 2013a).

infrastructure and reducing the risk of stranded assets (discussed further under Section 4.1.2.4), potentially increasing the cost efficiency of investments in renewables and energy efficiency measures (and others, such as reserve electricity generation capacity), potentially delivered through increasingly harmonised support mechanisms (further discussed in Section 4.4.1. The potential for future inter-State conflicts (expected and unexpected) is thus reduced (Held *et al*, 2015).

Innovation Union

The first 'State of the Innovation Union' report, published in 2014, concludes that the Innovation Union initiative is broadly succeeding in achieving its objectives. Of the 34 'action points' only one has not been achieved, or is not on track for achievement (namely, the requirement for Member States to set aside national procurement budgets for innovation, discussed further under Section 4.1.2.6) (European Commission, 2014). As such, **an option may be to produce an ambitious post-2020 'Innovation Union' Strategy**, which may include **'mission-driven' objectives for the development of key low-carbon technologies**. Such an approach would require **regular assessment of the state of key technologies across the energy system, and where R&D attention must be focussed**. Indeed, KAP 14 of the Energy Union states that 'the EU needs to develop a forward-looking energy and climate Research and Investment (R&I) strategy to maintain European technological leadership and expand export opportunities'. Under this KAP, the Commission will in 2015/16 propose a European energy R&I approach, comprising an upgraded SET-Plan, with 'a limited number of essential priorities and clear objectives' (European Commission, 2015b).

A review of the SET-Plan in 2012 concluded that it in order to be most effective, it requires, *inter alia*, an increased focus on energy system integration, and increased integration of activities along the innovation chain. As such, in 2013 the Commission proposed the development of an 'integrated' SET-Plan which will define priorities across the entire energy system through one consistent agenda at EU level, from research to market uptake. A Communication specifically addressing the future role of the SET-Plan is expected in September 2015[43], and is expected to contain the following (European Commission, 2015u):

- Identifies 10 actions for research and innovation, based on an assessment of the energy system needs and on their importance for the energy system transformation and the potential to create growth and jobs in the EU;
- Addresses for these actions the whole innovation chain, from basic research to market uptake, both in terms of financing as well as in terms of regulatory framework;
- Adapts the structures set up under the SET-Plan to ensure a more effective interaction with Member States and stakeholders;
- Proposes to measure progress as part of the annual reporting of the State of the Energy Union via overall Key Performance Indicators (KPI's), such as the level of investment in R&I, as well as specific KPIs to measure progress on the performance and cost-reduction for the priorities.

[43] The Communication had not been published at the time of writing.

Technology-specific assessments can provide guidance on the amount of support that should be channelled to both mature and innovative technologies, balancing R&D and deployment support (if required), reducing the potential for over-subsidisation (del Rio *et al*, 2015).

4.1.1.2 Establish Enabling Rules and Guidance for Public Investments and other Financial Market Actors and Investments

As discussed in Section 3.1.4, existing rules and guidance (or a lack thereof) for private and public investors (and other actors in the financial system) act as actual or potential barriers to unlocking the requisite flow of finance and investment to the development and deployment of low carbon technologies and infrastructure. As such, existing rules and guidance should be corrected where required, and introduced where appropriate, to ensure such flows are facilitated and encouraged. Various options are available, for application to public sector funds and institutions, the private sector, or both.

First, the **use of a 'social cost of carbon' (SCC) value in investments involving public funds and public financial institutions** may help prevent investments in at least the most highly CO_2-intensive assets. Whilst there is strong debate and disagreement in the literature regarding an appropriate value for the social cost of carbon (and appropriate discount rates), an option may be for the Commission to publish guidance on a value, or perhaps a range of values, to use. Such values could perhaps be made mandatory (as a minimum) for all EU level institutions (although the European Investment Bank (EIB) already employs a SCC in it's decision-making), and encouraged for adoption by public authorities and financial institutions in Member States. Over time, as real carbon prices increase (and potentially spread beyond existing sectors), such a requirement may be removed. An alternative, or complementary approach may be to prohibit investment in certain types of high-carbon infrastructure (e.g. unabated coal-fired power generation), with such requirements tightening over time (again, co-ordinated with the requirement for such rules, as the relative economic attractiveness of alternative investment options changes over time).

The use of suitable financial instruments, such as guarantees, grants and bonds, offered by public financial institutions, private finance and other businesses, is likely to be a key pillar in efforts to raise and direct appropriate finance (OECD, 2015), and their development should be encouraged. To facilitate this, **guidelines for the use of standardised and transparent Environmental, Social and Governance investment instruments (including 'Climate' and broader 'Green' Bonds), could be adopted** for use across the EU (and be mandatory for instruments issues by public funds and institutions). Such industry-led guidelines are already available[44], however the requirement for action by governing authorities (e.g. the Commission) to develop guidelines should be assessed. Indeed, this question was posed in a

[44] For more information, see: http://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/green-bonds/

consultation concerning the objectives and design of the proposed Capital Markets Union[45] (for which a summary of responses is yet to be published).

Basel III and Solvency II regulations, as discussed in Section 3.1.4, may be having unintended consequences on the ability of financial institutions to finance particularly long-term low carbon investments. However, to date there is a lack of data and empirical evidence to support these claims, and it may yet be too early for these effects to be detected given the relatively recent introduction of these regulations (indeed, Basel II only comes into full force in 2019). Despite this, the **EU could monitor whether such initiatives do indeed produce unintended consequences for financing the low-carbon transition** (OECD, 2015), and propose amendments where necessary. This would be simpler for Solvency II, which is an EU-only instrument.

To overcome information deficits that prevent an accurate assessment of the risks involved with particular investments (discussed under Section 3.1.4), **standards and requirements for integrated environmental, social and governance disclosure could be established** centrally by the Commission (OECD, 2015). At least initially, this could apply to firm from certain sectors, and of a certain size. At a minimum, such standards should include the disclosure of GHG emissions (discussed below). The disclosure of GHG emissions by firms has two potential effects. The first is that it requires initial measurement and quantification of emissions and their sources, to which little attention may have previously been paid. This may highlight, or allow for the identification of, measures that may already be cost-effective to introduce. The evidence for such a 'manage what you measure' effect is relatively strong (Grubb *et al*, 2014; Montabon *et al*, 2007). The second potential effect is that by providing such information to stakeholders and potential investors, the risks associated with an increasing carbon price, for example, may be appropriately assessed and investments altered accordingly. Both effects act to raise the prominence of GHG emissions in corporate decision-making (particularly in the shorter-term, in the absence of a substantial carbon price).

Such an instrument may be implemented in various ways. A model approach may be that taken in the UK, in which the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 requires all UK quoted companies to report on their GHG emissions as part of their annual Directors Report, from October 2013[46] (UK Government, 2015). Participants must report Scope 1 and Scope 2 emissions of all six GHGs defined in the Kyoto Protocol must be reported[47]. A GHG 'intensity ratio' must also be reported to normalise the values reported (Drummond, 2013b). However, as this Regulation is relatively recent, little assessment of the

[45] 'The Capital Markets Union (CMU) is a plan of the European Commission that aims to create deeper and more integrated capital markets in the 28 Member States of the EU. With the CMU, the Commission will explore ways of reducing fragmentation in financial markets, diversifying financing sources, strengthening cross border capital flows and improving access to finance for businesses, particularly SMEs' (European Commission, 2015w).

[46] This includes all UK incorporated companies listed on the main market of the London Stock Exchange, a European Economic Area market or whose shares are dealing on the New York Stock Exchange or NASDAQ.

[47] 'Scope 1' refers to direct emissions from activities owned or controlled by the organisation. 'Scope 2' refers to indirect emissions from the generation or production of the electricity, heat, steam and cooling purchased and used by the organisation. The six GHGs are CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.

impacts of these regulations has yet taken place[48]. Supplementary options are available, such as 'league tables' for sectors or sub-sectors to aid stakeholders with comparisons between organisations.

Such requirements may also provide guidance for additional climate-related disclosures. For example, disclosure of risk assessment procedures surrounding existing and prospective high-carbon assets (including mergers and acquisitions of other firms), whether organisations employ a social cost of carbon in the decision-making, and whether a climate risk management plan has been adopted, may produce additional benefit. Such guidance (and/or requirements) may vary across sectors, according to relevance and feasibility of holding, collating and reporting such information.

Whether such an instrument is introduced EU-wide for all qualifying organisations or implemented voluntarily by individual Member States depends on political feasibility. Regardless of what precisely is included in these requirements (and their legal basis), the provision of a standardised approach would allow for clarity and comparability, and reduce administrative burdens against the use of a range of different potential approaches.

4.1.1.3 Remove Barriers to Integrated Electricity Grid and Single Electricity Market

Electricity Transmission and Distribution Infrastructure

As discussed under Section 3.1.2, the first key hurdle to the development of an appropriate, EU-wide electricity transmission and distribution infrastructure is existing authorisation, planning and related procedural issues. Options for reducing or removing such issues are discussed in Sections 4.1.2.3 and 4.1.2.1. The second key issue is that of financing such infrastructure. At present, projects identified as PCIs (discussed under Section 3.1.2) are able to access the Connecting Europe Facility (CEF), which is expected to provide around €4.7 billion for such purposes, depending on the final configuration of the proposed European Fund for Strategic Investment. The European Fund for Strategic Investment (EFSI), proposed by the Commission in January 2015 and illustrated in Figure 6, is intended as the main vehicle for the Commission's Investment Plan[49]. It will employ €21 billion of public and European Investment Bank (EIB) funds to mobilise private finance with a desired multiplier effect of 15 to raise a total of €215 billion, largely for long-term investments (such as electricity interconnectors)[50]. The EFSI legislative proposal states that funded projects should not be

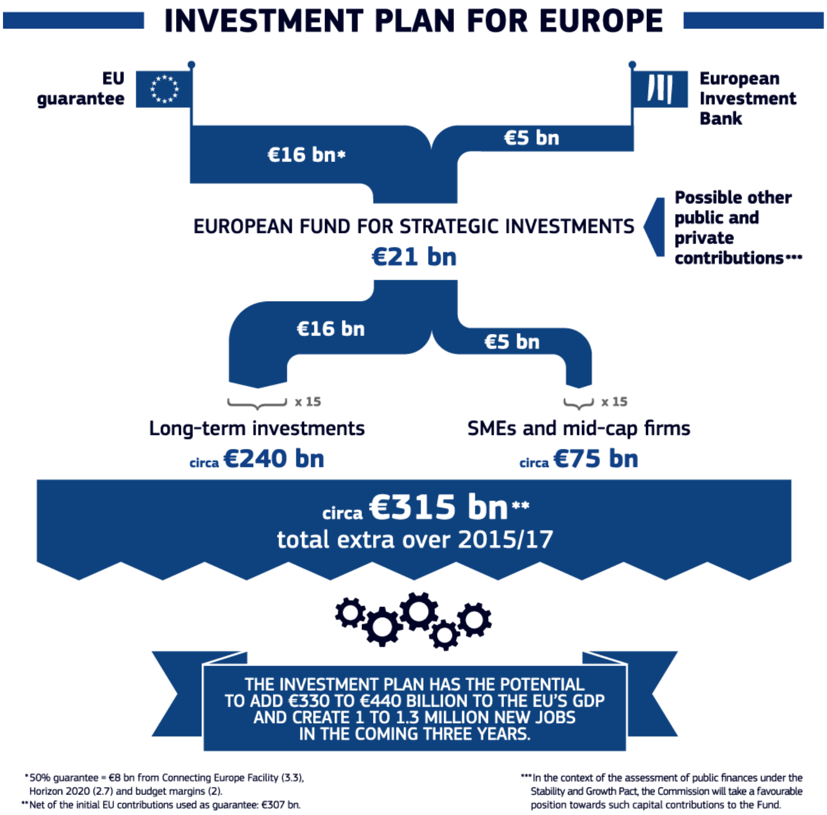
[48] It its *ex ante* estimates, DEFRA projects GHG savings of up to 4MtCO_2 by 2021 from this legislation, with annual cost savings to organisations estimated as up to £89 million (DEFRA, 2011).

[49] The Investment Plan focuses on removing obstacles to investment, providing visibility and technical assistance to investment projects and making smarter use of new and existing financial resources. The achieve these goals, the plan is active in three areas: (s) mobilizing investments of at least €315 billion in 3 years, (b) supporting investment in the real economy, and (c) creating an investment friendly environment (European Commission, 2015s).

[50] The legislative proposal states that the EFSI should target 'projects with a higher risk-return profile than existing EIB and Union instruments to ensure additionality over existing operations. (…) The EFSI should only be used where financing is not available from other sources on reasonable terms.'

limited to cross-border infrastructure, meaning that it may be also used to finance infrastructure internal to a single Member State. Due to the potentially (politically) infeasible continuation of on-bill cost recovery for transmission infrastructure investments, **the use of centralised EU funding may be a key option for ensuring the required investment takes place.** Indeed, financial support from European institutions for such investment is KAP 4 of the proposed Energy Union. Additionally, European Commission (2015k) reaffirms the target of interconnector capacity in each Member State equivalent to 10% domestic generating capacity (discussed under Section 3.1.2) to be achieved by 2020, with an increased minimum target of 15% to be achieved by 2030. The Commission also expects the 15% interconnector target to be delivered largely by the continued identification of PCIs, which are able to access central European funds and make use of other benefits described in Section 3.1.2, such as rapid authorisation procedures (European Commission, 2015k).

Figure 6 - Investment Plan for Europe (Source: European Commission, 2015l)



Electricity Market

As discussed under Section 3.1.2, the current electricity market design is unsuitable for an increasing penetration of renewables. As such, changes are required to ensure investment continues and security of supply is achieved. Energy Union KAPs 5 to 8 concern the development of an appropriate electricity market (European Commission, 2015b). In July 2015, a consultation was launched with the objective of proposing a new market design by the end of the year (the 'Market Design Initiative'), followed by legislative proposals in 2016 (KAP 5). The most appropriate design is fiercely debated, and it is beyond the scope of this report to discuss possible designs in detail. However, two general approaches are broadly possible, as summarised by Glachant and Henriot (2013):

- **'Melting Pot' Paradigm.** Once RES-E technologies begin to become competitive with conventional generation on a levelised cost of generation basis, support and capacity mechanisms are removed and RES-E generators are exposed to the same rules as other generators (e.g. bid to supply units of electricity, but also scheduling and balancing obligations). Proponents argue that the market will then find a new equilibrium position and associated prices able to stimulate the needed investments, along with optimal selection of RES-E generation sites, improvement of maintenance planning and technology combinations, control of production in extreme cases, higher efficiency of system balancing in general, incentives for innovation, better production forecasts and transparency. Wholesale prices would likely be highly variable (with clearance horizons likely much reduced from current day-ahead markets), with some installations seeking to recover investments through generation at times of particularly high demand (and high prices), for perhaps a few hours a year.

- **'Salad Bowl' Paradigm.** This approach considers the specificities of each type of generation (dispatchable and intermittent renewables), and applies different but complementary rules to each. Proponents of this paradigm consider the fundamental differences between these types of generation mean that a stable market equilibrium cannot be found, rendering a 'Melting Pot' approach unsuitable.

Each of these approaches has theoretical and practical benefits and problems (see Glachant and Henriot (2013) for a summary discussion of these points), and the decision on which broad approach is taken will depend on a range of factors, such as technical and political feasibility (including, for example, the level of control willing to be left to the market, the expected impact on investor confidence, and to whom the risks and costs burden will mainly fall), but also on the broad policy pathway taken in the short-term (discussed in Sections 4.2 and Section 4.3)[51] and the long-term.

However, two actions may be identified that would likely prove beneficial, regardless of the eventual specific design of the EU electricity market. Firstly, RES-E support and capacity mechanisms will be required at least in the near-term (and potentially in the longer-term). As such, these mechanisms must be optimised, as discussed in Section 4.4.1, below. Secondly, **full implementation of the Third Energy Package**, such as implementation of network codes, 'unbundling' of generators, suppliers and TSOs and the presence of 'open and fair' retail markets (including the removal of below-cost, regulated electricity prices), would be highly constructive. This forms KAP 6 of the Energy Union. The Commission will also 'seek the phasing-out of below cost regulated prices through the competition and economic

[51] Due to the nature of these two approaches, it is likely that the 'Melting Pot' paradigm matches most closely with the 'Incentive-based' policy pathway, whilst the 'Salad Bowl' approach matches with the 'technology-specific' pathway.

governance frameworks. It will also encourage Member States to establish a road map for the phasing-out of all regulated prices' (European Commission, 2015b). This could also include other distortions on electricity (and other energy) prices, such as reduced rate-VAT for domestic consumption in the UK (as discussed in Section 2.1.1).

As discussed in Section 3.1.2, above, only 8 Member States currently abide by the recommended minimum common technical requirements for electricity smart metering systems containing in Recommendation 2012/148/EU. To ensure interoperability and the possibility for demand side response measures in a future electricity market design, these **common minimum technical standard for smart meters may be made mandatory**. Indeed, the Commission proposes to 'continue to push for [such] standardisation' (European Commission, 2015b).

As the electricity market becomes increasingly unified and centralised, the role of ENTSO-E and ACER, and perhaps that of Distribution System Operators (DSOs) in the likely event of increasingly substantial decentralised generation, is likely to increase (Glachant and Henriot, 2013). As such, it should be ensued that such institutions are able to fulfil their required role. Such examination forms KAP 6 of the Energy Union (European Commission, 2015b).

4.1.1.4 Leverage Subnational and Regional Governance Institutions and Initiatives

As mentioned in Section 2.1.1, subnational authorities may hinder the decarbonisation ambition of a given Member State, depending on their legal and decision-making competence. However, the reverse may also be true; the ambition of local authorities may be hindered by the focus of instrumentation and resources at the Member State level, and the associated political economy[52]. By enhancing the role and prominence of sub-national governance institutions and initiatives (and regional, discussed below), city-level 'frontrunners' may emerge, functioning as policy and technology 'labs' from which lessons may be learned to broader application.

One institution that is well placed to facilitate and support such a process is the Covenant of Mayors (CoM). The CoM was created in 2009 as 'the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and the use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 20% CO_2 reduction objective by 2020'. It currently holds over 6,300 signatories, covering over 204 million inhabitants[53] (CoM, 2015). Signatories must prepare a Baseline Emission Inventory, and submit, within a year following their signature, a Sustainable Energy Action Plan (SEAP) outlining the key actions they plan to undertake. Various mechanisms allow for technical and administrative assistance, whilst 'Benchmarks of Excellence' act as a platform for sharing best-practice

[52] An example is that of Warsaw, Poland, a signatory of the Covenant of Mayors (discussed below), and Bristol, UK. See http://www.euractiv.com/sections/energy/warsaw-breaks-ranks-poland-2030-climate-goals-307987 and http://www.euractiv.com/sections/sustainable-dev/mayor-i-told-cameron-give-me-money-turn-bristol-lab-315627 , respectively, for more information.

[53] Mostly in the EU, although with around 200 signatories in non-EU countries.

techniques. van der Veen *et al*, 2013 found that the CoM is a successful initiative. In particular:

- **The CoM has played a strong role in involving local authorities in energy policy**, and in spreading the culture of CO_2 emission measurement and reduction in European municipalities.
- **The reduction in CO_2 emissions by signatories is relatively significant**. At the time of the review, a large majority of signatories (89%) expected their 2020 targets to be met.
- **The CoM provides various types of added value to signatories**, particularly regarding (a) their visibility and communication outside the city or towards the citizens, (b) the reinforcement of their capacity-building as a result of collective exercises to measure CO_2 emissions and to design actions to diminish them, (c) the political emphasis put on CO_2 emissions and (d) transfers of knowledge, know-how and experience from other signatories from different countries.

An option may be for the **CoM to extend SEAPs and measures to a 2030 horizon, and require signatories to at least meet the target of 40% CO_2 reduction below 1990 level**. It is possible that this requirement could be made stricter, such as requiring a minimum 50% projected reduction. Van der Veen *et al* (2013) also produce various recommendations to improve the effectiveness and efficiency of the CoM, including the provision of additional financing instruments available only to CoM signatories to assist in implementation of SEAP measures. Also, administrative support, capacity building and guidelines should be improved, including the provision of common monitoring guidelines.

4.1.1.5 Increase Monitoring and Application of Enforcement Mechanisms

As is clear from the description of the various 'challenges' discussed above (Section 3), non- and under-compliance by Member States with requirements set by EU Directives is a relatively pervasive issue, and forms a substantial hurdle to the low-carbon transition in many cases. Examples include the continued presence of regulated energy prices, low compliance with minimum energy performance standards for buildings, and non-compliance with requirements and deadlines with reporting obligations.

As such, a more vigorous **application of enforcement and penalty mechanisms to ensure Member States are in compliance with legally binding provisions should be a priority**. If compliance by Member States remains as currently with various Directives and provisions, any revision, reform or strengthening of requirements may prove ineffective. Indeed, the 'full implementation and strict enforcement of existing energy and related legislation is the first priority to establish the energy union' (forming KAP 1) (European Commission, 2015b).

4.1.2 Reform and Operation of Public Institutions

4.1.2.1 'Mainstreaming' of Low-Carbon Objectives

Ensuring low-carbon objectives are 'mainstreamed' into decision making across all levels of governance reduces the risk of the introduction of counterproductive instruments, incentives and investments, and enhances possible synergies with 'non-climate' instruments and initiatives that may (extendedly or unexpectedly) influence the low-carbon transition in some sectors. As discussed in Section 2.1.1, such non-climate instruments have been highly influential in some sectors (particularly agriculture). Administrative, public and political acceptability barriers that often act to prevent investment in low-carbon infrastructure in many Member States may also be reduced.

Achieving such an objective in practice may be difficult, although various options are available. The use of a social cost of carbon in policy and associated impact assessments for example (discussed in Section 4.1.1.2), may be one such option that may be applied to all levels of governance. At the EU level, the possible reforming of the Energy Union to an 'Energy and Climate Union', with an attached Vice President with a cross-cutting remit (discussed under Section 4.1.1.1, above), may be beneficial. This may be linked with the **reintroduction of a separate Commissioner for DG CLIMA and DG Energy**, which may help reduce the risk of propagating the risk that 'energy-only' matters are prioritised over 'climate' issues (Bausch *et al*, 2015). However, this must be balanced against the potential loss of the benefits associated with such a joint remit, given the indivisible link between the energy system and the low carbon transition. However, regardless of whether emission mitigation becomes the remit of both a Vice President and a dedicated Commissioner, or remains largely the portfolio of a combined energy and climate Commissioner, **increasing the role and prominence of DG CLIMA may be beneficial** in ensuring such issues are mainstreamed across EU level decision-making. As limited human resources have been emphasised as a crucial drawback in allowing DG CLIMA to play a more prominent role in the past (Bausch *et al*, 2015), an increase in staffing (and associated budget) may be required. This is also linked with the ability of the Commission to enhance information sharing, discussed in the following section.

At the Member State (and potentially local) level, **the introduction of crosscutting bodies such as the UK's Committee on Climate Change (CCC)[54] may be an option in some Member States**. Independent infrastructure planning bodies (discussed under Section 4.1.2.3) may also provide a similar function.

4.1.2.2 Regular Review and Dissemination of 'Best-Practice' Approaches

As discussed under Section 2.1.1, instrument design flaws have lead to some EU and Member State level climate policy instruments not exploiting their full potential (particularly economic instruments), others to produce additional cost without additional benefit, and yet others to

[54] The Committee on Climate Change (the CCC) is an independent, statutory body established under the UK's Climate Change Act 2008. Its purpose is to advise the UK Government and Devolved Administrations on emissions targets and report to Parliament on progress made in reducing greenhouse gas emissions and preparing for climate change. Specifically, its remit is to (a) provide independent advice to government on setting and meeting the UK's 'carbon budgets' and preparing for climate change, (b) monitor progress in reducing emissions and achieving carbon budget, (c) conduct independent analysis into climate change science, economics and policy, and (d) to engage with a wide range of organisations and individuals to share evidence and analysis (Committee on Climate Change, 2015)

be counterproductive. Such consequences act to reduce the overall effectiveness, increase costs and reduce the credibility of the instrument mix. **Monitoring and reviewing the design and impact of policy instruments and governance approaches across Member States to determine best-practice, and subsequent dissemination of this information**, may reduce or avoid this issue in future and **allow for more rapid policy learning and a more robust, effective, cost efficient and feasible policy mix and governance approaches**. An existing example is the provision of guidance for the design of renewable support mechanisms, published by the Commission in 2013 (discussed further in Section 4.4.1). Such guidance may be replicated regarding, for example, energy efficiency obligation schemes, labelling and other information instruments, and approaches to spatial planning and permitting procedures (discussed below). However, this may also require a substantial increase in resources for DG CLIMA (discussed above). Such guidance would also complement the existing requirements for BAT reference documentation under the Industrial Emissions Directive (discussed in Section 3.2.4), and information sharing platforms under the CoM (discussed in Section 4.1.1.4).

A key mechanism for promoting economic policy coherence within and between Member States is the European Semester. The European Semester is an annual cycle in which the Commission undertakes a detailed analysis of Member States' plans of budgetary, macroeconomic and structural reforms and provides them with individual, targeted recommendations for the following 12-18 months, with the objective of ensuring that the Europe 2020 targets are met, including the three headline targets of the 2020 Climate and Energy Package[55]. If recommendations are not acted upon within this timeframe, 'policy warnings' may be issued. Enforcement action may be driven through incentives or sanctions (European Commission, 2015n). **The continuation of an annual review of Member States' climate and energy policies and issuance of targeted recommendations for improvement to 2030 may be beneficial**, regardless of the mechanism employed to deliver it. Indeed, in the 2015 European Semester the theme of climate and energy was absent, as it is expected that this will be taken on as part of the Energy Union (European Commission, 2015o). Recommendations may focus on governance approaches, the design and combination of specific instruments and market distortions (such as misaligned company car taxation arrangements and fossil fuel subsidies). Irrespective of whether climate and energy-specific recommendations are provided as part of the European Semester or a separate process under the Energy Union, it must be ensured that recommendations that continue to be provided under the Semester process for other subjects or objectives are aligned with the low-carbon transition. This may be assisted by, and contribute to, the 'mainstreaming' objective, discussed above. It also contributes to the objectives of the Innovation Union, discussed in Section 2.1.2.3.

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[55] The five Europe 2020 targets are: (1) 75% of the 20-64 year olds to be employed, (2) 3% of the EU's GDP to be invested in R&D, (3) the three headline targets of the 2020 Energy and Climate Package, (4) Reducing the rates of early school leaving below 10% and at least 40% of 30-24 year olds completing third level education, and (5) at least 20 million fewer people in or at risk of poverty and social exclusion (European Commission, 2015p).

4.1.2.3 Ensure Clear and Appropriate Spatial Planning Regimes and Administrative Competence

The design of spatial planning regimes and other authorisation procedures have proven a hindrance to the deployment of various types of infrastructure in many Member States, as discussed above concerning renewables and electricity transmission and distribution infrastructure (Sections 3.1.2 and 3.2.1).

Spatial Planning Approaches

A spatial planning regime that allows for low-carbon options and development, and that integrates different aspects of land-use planning (such as housing, transport and energy generation and supply), may be crucial in facilitating the low-carbon transition. For example, limits on building height in cities, for example, may cause urban sprawl and increase transport demand and thus emissions (along with restricting the viability of active transport options) (OECD, 2015). As spatial planning is a Member State competence in full, such reforms must be instituted by national governments (and relevant sub-national authorities). However, the Commission may provide guidance and share best-practice examples (as discussed under Section 4.1.2.2). Initiatives such as the CoM may also be leveraged to advance such reforms and disseminate lessons-learned. Parallel reforms, such as property taxation, may also be of substantial benefit. For example, property tax levied on buildings and other land improvements rather than on land values may make suburban greenfield development more attractive than urban brownfield development in many cities and Member States (OECD, 2015).

Administrative Integration and Clarity

As discussed in Section 3.1.2, the number of jurisdictions certain infrastructure must pass through (particularly electricity transmission infrastructure), and the complexity and unpredictability of processes and decision making in each, is often a substantial barrier to infrastructure development. Whilst the creation of 'one-stop-shops' for authorising inter-Member State transmission infrastructure has been largely achieved, this is not the case for sub-national transmission or other types of infrastructure in many Member States. Therefore, **responsibility for infrastructure planning and authorisation and could be concentrated in a single body at key levels of governance, with the distribution of competence made clear, along with processes for dispute resolution processes where required**. For example, a National Infrastructure Authority may be instituted, with Municipal Infrastructure Bodies acting at the local level (e.g. cities, states or regions). At the national level, at least, such bodies may be semi-independent of government. This would allow for long-term, holistic infrastructure planning with uncertainties produced by political cycles and interactions between various authorities and departments, reduced.

As well as functioning as a 'one-stop-shop' for various forms of permitting (including renewables), such bodies may also be a focal point for stakeholder engagement. Effective public participation strategies and understanding of local attitudes is often cited as a priority for reducing barriers to the deployment of renewables (del Rio et al, 2015).

4.1.2.4 Produce Long-Term Infrastructure Plans

As discussed in Section 3.1.3, various Directives require Member States to produce plans for how their provisions are to be met (concerning both infrastructure to be deployed, and policy instruments to achieve such deployment). Such plans are generally only required to consider a time horizon for which mandated targets or requirements are in place - often 2020.

In order to ensure Member States consider how they intend to achieve decarbonisation in the longer-term, **it may be prudent for Member States to produce comprehensive, integrated national infrastructure and policy plans**, with iterations produced on a pre-defined timescale (e.g. every 5 years). Such plans may cover key elements and sectors of the energy system (e.g. power generation, buildings, transport, etc.), with specific requirements or guidance on what to include perhaps defined by the Commission[56], and would remove the need for the production of independent parallel plans for different, but interrelated purposes. Indeed, the Commission recognises the need to simplify and streamline the requirement for such separate processes, and has proposed a consolidated approach through the production of 'National Plans for Competitive, Secure and Sustainable Energy' as part of the governance framework for the 2030 Package[57]. The specific time horizon for such plans must be carefully considered. For example, whilst 2030 would certainly be appropriate for some sectors for plans produced prior to 2020, for others it risks irrelevance as technological developments and other uncertainties may render any planning beyond broad generalities particularly difficult. Regardless, such long-term, comprehensive planning would likely have multiple benefits. It would ensure that Member States appropriately consider all key aspects of their decarbonisation pathway and options available in an integrated fashion, reducing the risk of stranded assets and excessive cost, and reduce the potential for reciprocal barriers to certain developments (e.g. the 'chicken and egg' situation concerning renewable generation and grid infrastructure). Such plans may then be assessed by the Commission to determine, in particular, synergies and conflicts with neighbouring Member States, and suggest changes where appropriate. Such plans may facilitate co-operation between Member States, and allow for combined efforts and policy measures to meet regional renewable or energy efficiency targets, for example (as discussed under Section 4.1.1.1). They may also feed into EU-level planning mechanisms, such as the TYNDPs. National Infrastructure Authorities discussed in the previous section could be responsible for producing such plans. Local plans may also be produced by Municipal Infrastructure Authorities, and be linked to Member State-level plans to ensure consistency.

4.1.2.5 Provide Dedicated Funding Sources for Low-Carbon Infrastructure, Deployment and Innovation

Whilst establishing broad rules and guidance for public funds and financial institutions (discussed under Section 4.1.1.2, above) is a step towards enabling the appropriate

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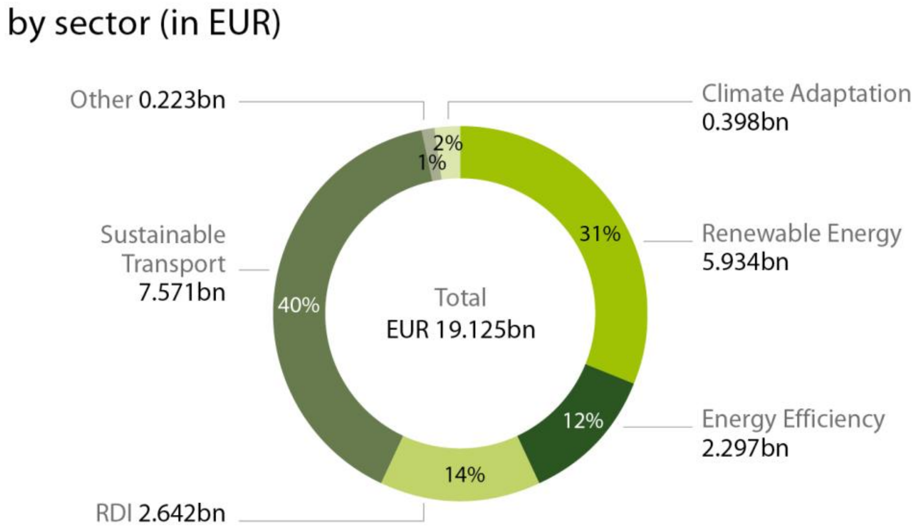
[56] The level of detail possible to provide would likely depend on which of the two pathways presented in Sections 4.2 and Section 4.3, below, are pursued.
[57] See European Commission (2014a) for more information.

availability and flow of finance, **providing dedicated funding sources and financial institutions with a specific mandate to invest in and provide and finance for the low-carbon transition** would likely provide additional benefit. Indeed, the role of public finance and public financial institutions is likely to be critical in stimulating the low-carbon transition, by facilitating access to long-term financing, reducing project and financial risks, attracting investment from the private sector, and in filling the 'capacity gap' (i.e. providing expertise to support low-carbon investments and market development (OECD, 2015).

The EIB currently commits to investing at least 25% of its lending portfolio in climate action (although not exclusively in the EU or neighbouring states). In 2014, this value totalled €19.1 billion, broken down by various sectors, including around 14% to RDI (Research Development and Innovation), as illustrated by Figure 7.

Figure 7 - EIB Climate Action Lending 2014 (Source: EIB, 2015a)



Central EU funds, such as Cohesion Policy and the framework programme for research funds (the most recent of which is 'Horizon2020', discussed under Section 3.2.4), are also relatively significant sources of dedicated funding. The proposed EFSI, as briefly described in Section 4.1.1.3 and illustrated in Figure 6, above, is also likely to be a significant source of funding. Indeed, EFSI is intended to focus on four areas: (a) strategic infrastructure (including energy, transport and digital), (b) education, research, development and innovation, (c) expansion of renewable energy and resource efficiency, and (d) support for smaller businesses and mid-cap companies (EIB, 2015b).

Under the options presented in this report, additional funds are available from proposed strengthening of GPP requirements (discussed under Section 4.1.2.6), and proposed earmarking of revenues from the EU ETS (discussed under Section 4.3.1). However, **whether such funds, instruments and institutions (both existing and proposed) are effective and sufficient should be regularly reviewed.**

To be effective, the availability of such funds must be advertised to potential recipients and co-investors, and presented in a coherent manner. Three recent Commission proposals seek to achieve this. Firstly, the Commission intends to 'work with Member States and regions to ensure synergies between the different EU funds, and to exploit the potential of Cohesion Policy funding for innovation' (European Commission, 2015b). Secondly, the European Investment Project Portal (EIPP) – a web portal to clearly list potential investment opportunities in the EU to give 'clarity and confidence to investors' – is currently under development (European Commission, 2015x). Thirdly, a 'Smart Financing for Smart Buildings' initiative, which aims to 'facilitate access to existing funding instruments' for energy efficiency in existing buildings, is also under development (European Commission, 2015b). **It should also be ensured that such 'transparency' mechanisms are also fit for purpose.**

An option to complement EU level funding may be through the **establishment of public financial institutions with explicit mandates for low-carbon investment**. Various countries and EU Member States have established such institutions in recent years, with primary examples being KfW in Germany, and the Green Investment Bank in the UK. Such examples are 'scaling-up private investment in green infrastructure, and creating a track record for investment in clean energy' (OECD, 2015).

4.1.2.6 Enhance the use of Green Public Procurement

Public authorities are major market actors in the EU, with their spending equivalent to around 19% of the EU's total GDP (European Commission, 2015v). As such, through their purchasing power they have the potential to provide and drive the market for both mature and innovative low-carbon, high-efficiency products and services across a range of sectors. EU policy for green public procurement (GPP) is based on the 2008 Communication 'Public Procurement for a Better Environment', which required the Commission to produce common criteria for GPP for different products for voluntary adoption by Member States, and set an EU-wide indicative target that by 2010, all public tendering procedures should be compliant with GPP criteria for priority product/service categories (European Commission, 2008). Renda *et al* (2012) found that in 2010, this value was only 26%, and that the use of GPP criteria varied very significantly across Member States)[58]. As discussed in Section 4.1.1.1, the use of procurement funds to directly encourage innovation is not on track to meet objectives under the Innovation Union.

As such, **the uptake of GPP should be enhanced**. As part of the Energy Union reforms, the Commission has stated its intention to 'explore how public procurement can exploit its potential to act as a catalyst for industrial and business innovation, and green growth both within the EU and beyond its borders' (European Commission, 2012b). **The use of Forward Commitment Procurement (FCP) may be of particular benefit**. FCP commits government to purchasing goods or services that meet a given performance standard that is currently not yet available (UCL GEPC, 2014), providing a market for such products and services and

[58] However, provisions in other Directives, such as the Clean Vehicles Directive, the Energy Labelling Directive and Energy Efficiency Directive, support these voluntary guidelines; although there are usually subject to flexible cost-benefit clauses, which reduces their stringency.

incentivising their development. The concept was developed in the UK, from which various examples demonstrate FCPs successfully facilitating the development of innovative products (BIS, 2011).

One approach to enhancing the role of GPP would be through proposing and introducing mandatory requirements. However, the (political) feasibility of this option is questionable. The alternative is to encourage and incentivise voluntary uptake of GPP, for example through information sharing platforms and initiatives, and initiatives for joint procurement (increasing purchasing power). For sub-Member State public authorities, initiatives such as the CoM may have a similar impact (e.g. cities may share information and issue joint procurement agreements).

4.2 Policy Pathway One – 'Incentive-Based'

This pathway focuses on pricing and other technology-neutral incentivising instruments to drive low-carbon investments and behaviour. A strengthened and expanded EU ETS is the primary instrument and cornerstone of the instrument mix. Unless explicitly stated otherwise, existing regulatory requirements and targets largely remain, but are not tightened (e.g. minimum energy performance standards for buildings) and many expire once time-limited targets are met (e.g. Fuel Quality Directive targets, energy efficiency obligation schemes, CO2 intensity targets for passenger cars and LGVs, etc.).

4.2.1 Structural Reform and Expansion of the EU ETS

Despite the modest abatement produced by the EU ETS thus far, and the various issues that currently inhibit its ability to produce a substantive carbon price now and into the future (i.e. late 2020s), it remains the most appropriate instrument through which a substantive carbon price may be established (particularly for the sectors it already covers). Administrative processes are already in place, initial legal barriers and challenges have been overcome (Mehling *et al*, 2013), and those subject to it now broadly accept its presence. Whilst reforms to produce a substantive, increasing and more predictable carbon price would (and already have) meet with resistance (and reduced associated political feasibility), the ETS likely remains the most acceptable and otherwise feasible instrument in the short-term. As such, the strengthening of the EU ETS should be the first priority for the evolution of the instrument mix (in both policy pathways presented).

Options for Structural Reform and Expansion

A first attempt to tackle the existing surplus of allowances was through the implementation of 'backloading' of permit auction volumes over 2014 to 2016[59], to be made available instead in 2019-2020. However, whilst this restricts allowance supply in the short-term, as these allowances are to be returned to the market later in Phase 3, backloading did not change the total supply of allowances, and hence failed to address the core of the problem. As such, in

[59] 900 million in total - 400 million in 2014, 300 million in 2015 and 200 million in 2016.

2012 the Commission released a report on the 'State of the European Carbon Market', which identified six options for structural reform (European Commission, 2012a). Two of these six suggestions have progressed:

- **Discretionary Price Management Mechanisms.** Essentially, such measures seek to influence the price produced by the EU ETS, and as such move from a pure cap-and-trade to a hybrid instrument. A legislative proposal put forward in January 2014 proposed the creation of a '**Market Stability Reserve' (MSR)**. The proposal was approved by the European Parliament (with some design amendments) in July 2015, and subsequently approved by the European Council. If such approval is received, the MSR will therefore become operational in 2019. The MSR will function by triggering adjustments to annual auction volumes based on clear rules. Where such conditions are met, permits equal to 12% of those in circulation may be deduced from auction volumes in any given year, and placed in the Reserve. Similarly, 100 million permits will be released (if available) and made available for auction above normal volumes when the volume of permit circulation is fewer than 400 million. Additionally, all 'backloaded' allowances will be entered directly into the MSR. Permit prices are therefore influenced by proxy, through altering permit supply dynamics.
- **Revision of the annual Linear Reduction Factor (LRF).** At present, the total issuance of permits (both auctioned and freely allocated) decreased at a rate of 1.74% of the average total quantity of permits released annually in 2008-2012. However, in order to achieve the required contribution towards the 40% GHG reduction target for 2030 from the EU ETS sectors (discussed in Section 2.1.2.1), this value will increase to 2.2% from 2021.

Broadly, such actions appear to be sensible options in in the short-term to tackle the permit oversupply and begin to produce a more substantive, stable and credible carbon price signal. Under this 'incentive-based' policy pathway, such interventions should aim to achieve a carbon price of at least €70 by 2030[60]. However, discussion of whether the specific combination of these structural amendments will produce such a price, and thus whether their designs are suitable or stringent enough, is beyond the scope of this report.

Another of the options for structural reforms proposed by European Commission (2012a) was sectoral expansion to sectors whose emissions are less strongly influenced by economic cycles. Whilst not taken forward as a legislative proposal by the Commission, such an option may be highly beneficial under this policy pathway. Discussion surrounding expansion of the EU ETS has focussed largely on road transport fuels and heating fuels. Whilst an expansion to the road transport sector may be beneficial in the long-term, it is unlikely to be the most appropriate option for extending the reach of carbon pricing in the shot-term (discussed below, in Section 4.2.2). However, expansion to heating fuels – particularly natural gas in the

[60] As discussed under Section 3.1.1. However, as many of these models assume perfect markets, or otherwise do not characterise well market failures that reduce the effects of a price signal, a higher value may be required in practice to achieve the same ends envisaged by the models. However, many of the reform and instrumentation options presented for this policy pathway, and in Sections 4.1 and 4.4, may help to reduce or overcome such issues.

residential sector - may be a desirable option in the short-term. The residential sector accounts for around 28% of natural gas consumption in the EU (a higher proportion than any other individual sector, including power generation at around 19% (excluding CHP)), whilst natural gas accounts for around a third of residential energy consumption (the highest proportion of any individual energy carrier) (European Environment Agency, 2015d), with the vast majority used for space and water heating. As such, it is an important source of CO_2 emissions that remains unpriced, and which must be substantially reduced over time[61].

At present, domestic heating fuels may be exempt from taxation under the Energy Taxation Directive (except VAT). Whilst only six Member States provide full exemptions to natural gas[62], only thirteen levy rates that exceed an equivalent of a €10/tCO_2 carbon price (excluding VAT). Expanding a strengthened EU ETS to natural gas use in the residential sector would then ensure a carbon price signal is received, encouraging a shift away from natural gas to higher energy efficiency and low-carbon energy in both new and existing buildings, and tackling the potential for continued fossil fuel lock-in in the sector.

Figure 8 - Residential Natural Gas Carbon Price Projections - 2030 and 2050 (Source: Drummond, 2015)

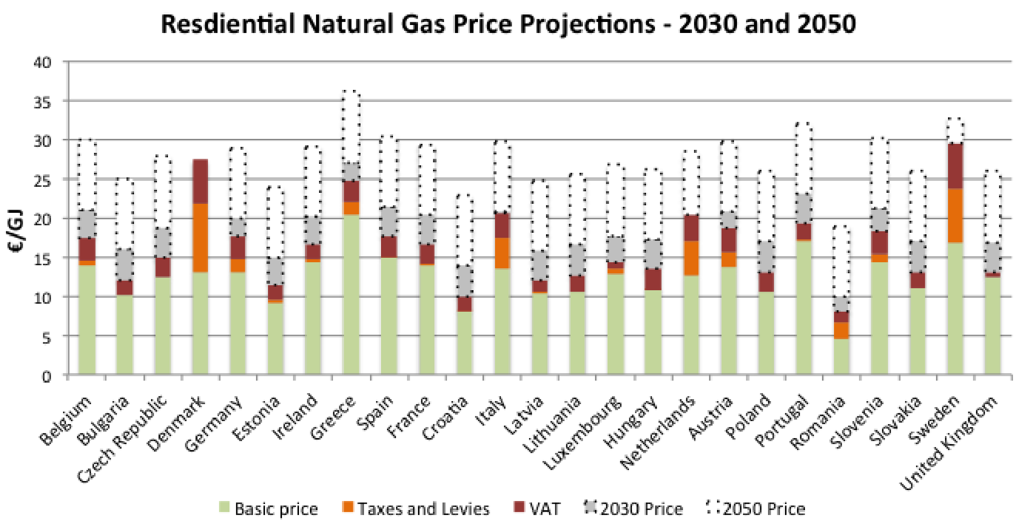


Figure 8 illustrates the potential effect of an expanded EU ETS on residential natural gas prices across the EU, with a €70/tCO_2 carbon price in 2030, and €250/tCO_2 in 2050. The values for basic prices, taxes and levies and VAT are averaged over a seven-year period (2007-2013). Projected values for 2030 and 2050 represent total (additional) cost, with the assumption that gas prices maintain a constant average, and existing levies (except VAT) are reduced to offset the EU ETS price (entirely if possible)[63]. Under these assumptions, an

[61] Whilst the pricing of CO_2 from other heating fuels, such as coal and oil, would also be beneficial from the perspective of environmental effectiveness and cost efficiency, their relatively minor (and decreasing) contribution to domestic energy demand renders them a lower priority.

[62] Bulgaria, Czech Republic, Lithuania, Poland, Slovakia and the United Kingdom.

[63] Data for Cyprus, Malta and Finland is not available. A CO_2 intensity value of 0.051tCO_2/GJ for natural gas was applied. Data for Band D2 (20GJ to 200GJ) were used. The cost imposed by VAT would also change as a result of carbon prices/ (with the equivalent sign), however this change is not calculated. For Taxes and Levies, only non-recoverable values are used.

average price increase of 13% is projected by 2030 (with significant variation, including no increase in Denmark, Italy, the Netherlands, and Sweden)[64] (Drummond, 2015).

Modelling evidence suggests that such a carbon price could be highly effective in fostering energy efficiency retrofits (in particular) and the uptake of renewables in the building stock, particularly in owner-occupier dwellings (approximately 70% of households in the EU (Bouyon, 2015)). However, in the rented sector, only the most inefficient are retrofitted (Nauleau *et al*, 2014). As such, to maximise the effectiveness, cost efficiency and feasibility of such a sectoral expansion, measures to overcome issues such as the landlord-tenant dilemma (such as continued energy efficiency obligations, or increasingly stringent minimum energy performance standards), and the use of compensatory mechanisms to counter the (likely regressive) increase in energy prices, would likely be required. Additionally, care would have to be taken to redefine the EU ETS cap, to maintain confidence in expected future prices.

For this expansion to be administratively feasible, the point of obligation should be upstream (e.g. with the supplier), rather than individual emitters, as is currently the case with existing EU ETS sectors. This would also allow for natural gas used for other domestic purposes (e.g. cooking), and in other sectors (e.g. commercial and public, or smaller industrial installations currently exempt from the EU ETS under *de minimis* conditions) to be included within the scope of the EU ETS. If the point of obligation is shifted yet further upstream (i.e. at point of production or import), then the power and industrial sectors may also be included under this single administrative approach.

Whilst the above options strengthen and expand the carbon price produced by the EU ETS, various operational features and concessions (discussed in Section 3.1.1) mean that many installations in the industrial sector are not fully subject to the existing carbon price. As such, steps must be taken as far as possible to address this.

- **Introduce full auctioning to non-EITE sectors by 2030**. At present, the proportion of permits freely allocated to the non-EITE (manufacturing) sectors is set to decrease to 30% by 2020 (from 80% in 2013), based on the 'benchmarking' process described in Section 3.1.1. Under current proposals, this is set to continue to 2030 (although with more frequent updating of benchmark values to reflect changing technological capacity and progress) (European Commission, 2015f). Under this policy pathway, this could change to a linear reduction from 30% in 2020 to zero by 2030. Compensation to electricity-intensive firms remains a Member State competence and prerogative, under state aid restrictions.
- **Improve definition and targeting of EITE sectors**. At present, sectors accounting for more than 97% of industrial EU ETS emissions are considered EITE sectors, and thus at risk of carbon leakage and eligible for free permit allocation of 100% of the benchmark value (European Commission, 2015g). In order for the increase in auction volumes to be effective (as suggested above), this proportion must be reduced. The Commission has

[64] By 2050, an average price increase of 77% is projected, again with significant variations (including no increase in Denmark).

proposed changes to the rules that determine which sectors are listed as at risk of carbon leakage[65], which will reduce their number from 177 currently to around 50 from 2021. However, given the sectors that will remain on the list, the proportion of CO_2 emissions receiving free allocation remains high. The political feasibility (and desirability) of reducing this list further appears limited in the short-term. As such, potential alternatives to 100% free allocation to these sectors must be advanced.

- **Alternative options for carbon leakage protection measures**. At present, sectors that receive 100% free allocation are subject to little incentive to reduce CO_2 emissions, aside from the opportunity cost of the permits freely received (which with low prices, is not significant). Additionally, due to their high trade intensity and level of international competition they are subject to, this (opportunity) cost is not passed-through to product prices, thus producing no incentive for consumers to seek lower-carbon alternatives (Neuhoff *et al*, 2014a). A commonly proposed option to solve these issues is the use of Border Carbon Adjustments (BCAs), in which the carbon price is refunded to products exported, whilst those imported from regions lacking a (comparable) carbon price are subject to an import tariff of equivalent value. Such border levelling would effectively prevent carbon leakage and allow cost pass-through. However, compatibility with World Trade Organization (WTO rules) is unclear, and political feasibility is questionable (Antimiani *et al*, 2015). Whilst a BCA approach may be an appropriate solution in the long-term, for the short-term an alternative is required.

  A combination of output-based allocation (OBA) with domestic indirect 'consumption charges' may be one such alternative. Under OBA, free allocation would remain, but be distributed to sectors at risk of carbon leakage on the basis of units of (recent) production and a 'best available technology' benchmark, rather than historic emissions of individual installations (as proposed by the Commission, discussed above). This would be coupled with an indirect consumption-based charge, based on the CO_2 intensity of the consumed product and linked to the EU ETS price. Such a charge would not be applicable to products sold to non-EU consumers, and would apply to products imported from non-EU producers (with the liability created at the point of production or import, but only due when released for consumption).

  As such, this combination has the potential to prevent carbon leverage whilst providing an incentive for reduced CO_2 (and energy) intensity by producers, and by establishing a price signal for (domestic) consumers, an incentive for efficiency and product substitution

[65] 'Sectors and sub-sectors where the product exceeds 0.2 from multiplying their intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the European Economic Area (annual turnover plus total imports from third countries), by their emission intensity, measured in kgCO2 divided by their gross value added (in €), shall be deemed to be at risk of carbon leakage; **or** where the product from multiplying their intensity of trade with third countries by their emission intensity is above 0.18 on the basis of a qualitative assessment using the following criteria: a) the extent to which it is possible for individual installations in the sector or sub-sectors concerned to reduce emission levels or electricity consumption; (b) current and projected market characteristics; (c) profit margins as a potential indicator of long-run investment or relocation decisions' (European Commission, 2015g).

downstream (within the EU). The use of an indirect consumption charge has various benefits over the use of a direct production, consumption or import tax. Following the principle of destination, and being internationally neutral, non-discriminatory and in line with 'national treatment' requirements, WTO compatibility is likely. From an EU perspective, as a 'parafiscal' charge, this instrument is not considered 'primarily of a fiscal nature', that would require unanimous support by the European Council. Instead, a qualified majority vote would suffice[66]. Consumption charges are long established and widely implemented on various products (including alcohol, tobacco and fuel), and thus are considered to be highly administratively feasible (Neuhoff *et al*, 2014a; Neuhoff *et al*, 2014b).

Use of Auction Revenues

At present, 90% of ETS revenues go directly to Member States, at least 50% of which (or equivalent financial value) 'should' be used for climate and energy related purposes (Member States are currently well in excess of this (non-binding) target). The remaining 10% of auction revenues are distributed as additional funds to 'less wealthy'[67] Member States (via additional EUA allocation). Under existing proposals for 2021 onwards, this additional 10% is set to continue.

The existing proposals for EU ETS reform however include additional mechanisms that earmark additional revenues at the EU level for specific purposes (thus reducing the proportion of revenues allocated to Member States and used at their discretion). The first is a 'Modernisation Fund', in which an additional 2% of revenues are to be distributed to ten 'low-income' Member States[68], to 'improve energy efficiency and to modernise the energy systems of [these] Member States' (European Commission, 2015f). The second is an 'Innovation Fund'. The Innovation Fund, intended to begin in 2021, is an extension of the current NER300 facility[69], with a proposed initial endowment of 400 million allowances. The scope of funding will be extended from the power sector to also include industrial sector innovation. Such a mechanism is likely to be beneficial in the long term, as evidence suggests the uses of direct financial support in this manner would help prevent 'innovation investment' leakage (Antimiani *et al*, 2015).

However, additional revenues reduced from those currently distributed to Member States and earmarked centrally for a focussed purpose could produce additional benefit in the short- to long-term. For example, **additional revenues could be earmarked at the EU level to**

[66] In contrast to a tax (falling under TFEU 192 para 2), which is easily adjustable by government and usable for general government expenditures, a levy is classified as a 'parafiscal charge' (falling under TFEU 192 para 1) when revenues are earmarked, assigned to a body governed by public law, and does not contribute to the national budget. As such, revenues from this charge should be collated in a Member State-level public 'trust fund', with revenues earmarked for climate purposes.

[67] GDP per capita that does not exceed 90% of the EU average (in 2013).

[68] GDP per capita that does not exceed 60% of the EU average.

[69] 'NER300', funded from the sale of 300 million permits from the New Entrants Reserve, was set up in Phase 3 to provide funding for demonstration projects in the power sector (specifically CCS and renewable technologies).

directly support renewable energy and energy efficiency deployment across Member States. Such funds could be distributed proportionally to Member States (or regions) that commit to meeting or exceeding their benchmark target values for renewables and efficiency (as discussed under Section 4.1.1.1, above), and provide an incentive in the absence of binding targets. For funds used specifically for renewable electricity, this would contribute to the reducing wholesale electricity prices via the merit-order effect (under the current market design), whilst also reducing support mechanism costs, and thus the cost of compensatory measures to all sectors. Other instruments, such as support mechanisms for renewable heating and cooling and energy efficiency measures in the residential sector, may also be funded from this additional revenue stream (and allow for compensation to some degree from the inclusion of natural gas in the residential sector in the EU ETS).

The level to which this would reduce the total proportion of auction revenues distributed to Member States would depend on the specific design of each of these options. However, due to the structural reforms producing higher prices, sectoral expansion and the inclusion of consumption charges for sectors at risk of carbon leakage, the total value of revenues received are likely to be significantly more substantial than currently experienced.

4.2.2 Introduce and Harmonise Carbon Price Signal in the Road Transport Sector

Although not proposed for inclusion under the EU ETS in the short-term, under this policy pathway the introduction (or strengthening) of a carbon price must be considered in other key sectors; particularly road transport (currently accounting for nearly a quarter of CO_2 emissions in the EU).

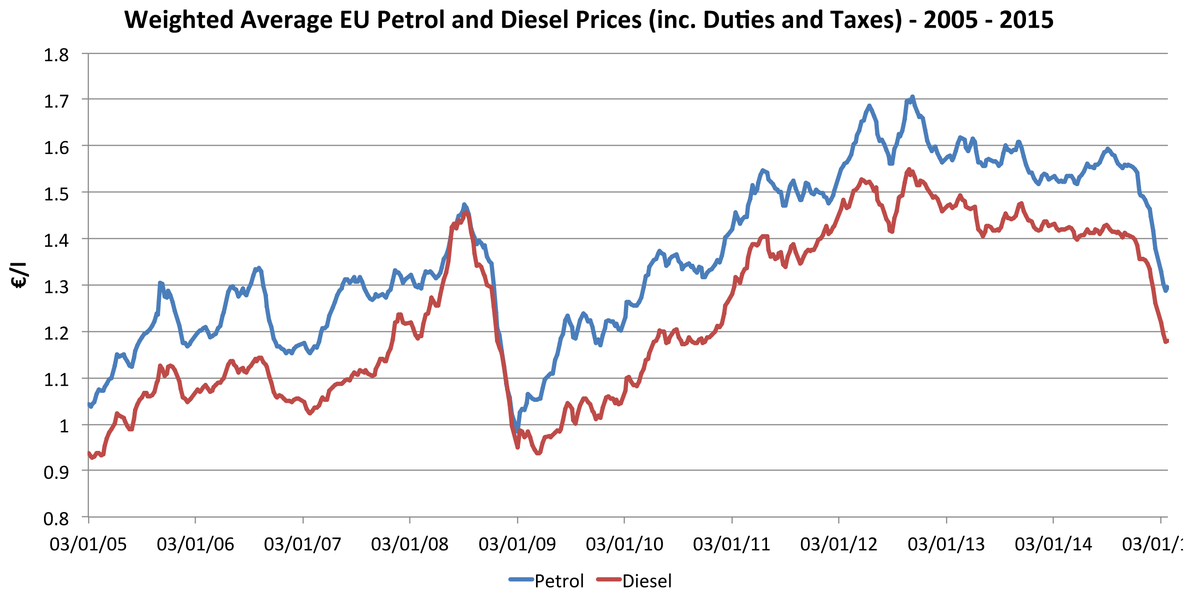
Implementing a carbon price on the source of the externality, the fossil fuel combusted to propel vehicles, would seem the logical choice to achieve this. As discussed in Section 0, whilst the ETD places minimum taxation values on transport fuel, the values are not intended to internalise CO_2 emissions (and as such are not tied to carbon content), and the actual values levied by Member States are highly varied (see Figure 5). This produces different price signals, and encourages fuel tourism. However, it must be noted that many Member States that set values above the minima do so at least in part to internalise CO_2 emissions, although very few publically state the proportion of the levy applicable to CO_2 emissions or to other transport-related externalities (e.g. local air pollutants).

There are two clear options to introduce a carbon price on transport fuels. The first is via inclusion in a strengthened EU ETS (applied upstream at suppliers, producers or importers), and the second is via a revision of the ETD, as proposed by the Commission in 2011. The proposal (COM(2011) 169/3) suggests a revised minima for all fuels, set as the sum of an 'energy' component, which would set a minimum value based on energy content (€9.6/GJ for transport fuels), and a 'carbon' component, applicable across all energy products (except electricity), which would be revised on a regular basis to follow the evolution of the carbon price generated by the EU ETS (Drummond, 2013a).

However, neither of these options are necessarily desirable in the short-term. Regardless of which mechanism is used to internalise a carbon price to transport fuels, even if the existing ETD minima remains the same with the carbon price fully additional, existing tax rates in addition to the minima in many Member States are already higher than the additional cost a €70/tCO_2 carbon price would impose. This is particularly the case for petrol, for which 13 Member States levy rates higher than an equivalent €70/tCO_2 carbon price, in addition to the minima (although for diesel, only two Member States levy such rates). As such, if a revised ETD imposed such a carbon price, many Member States would already be in compliance (although administrative changes may be required), and if imposed by the EU ETS, national levies may be reduced to compensate.

Two further issues remain. The first is of political feasibility; for example, the proposed revision of the ETD has not yet progressed, and would require unanimity to introduce. The second is that of basic fuel price volatility. Figure 9 illustrates the range of weighted average petrol and diesel prices in the EU between 2005 and 2015. It is clear there has been significant volatility in weighted average prices over the last decade, largely driven by trends in oil prices (with duties and taxes remaining largely static), with the differential between peak and trough prices at €0.62/l for diesel, and €0.72/l for petrol (Drummond, 2015). These values are approximately the same magnitude of additional cost that would result from a €250/tCO_2 carbon price.

Figure 9 - Weight Average EU Petrol and Diesel Prices for the EU28 - 2005-2015 (Source: Drummond, 2015)



As such, underlying fuel price fluctuations and relatively high levies rates already exhibited by many Member States mean that in the short-term, introducing a carbon price on transport fuel is unlikely to produce a price signal to encourage an increase in the rate of shift towards low-carbon transport (even if politically feasible). This is particularly the case given evidence that in the short-term, for passenger cars, fuel prices are effective at reducing demand for transport (i.e. distance driven), but have little influence on initial vehicle purchase decisions (Nijland *et al*, 2012). Nevertheless, such efforts to introduce an equalised carbon price for transport fuels would be of value, as the importance of these factors in the short-term reduces as carbon prices rise in the longer-term. This would also have the effect of reducing fuel price differentials, reducing the incidence of fuel tourism.

However, in order to encourage short-term action as a basis for securing a long-term transition, alternative action must be taken to send the appropriate carbon price signal, particularly to influence vehicle purchase decisions and reduce fuel tourism. Two options may be available to achieve this. The first is the **reform of vehicle registration and circulation taxes to consider CO_2 intensity as a primary factor, and extend to all road vehicles across all Member States**. As discussed in Section 0, a high proportion of Member States already levy registration taxes on passenger cars (with very highly varied values), with CO_2 intensity considered as a parameter in around two-thirds of these. Few Member States levy registration taxes on other road vehicles. By reforming existing rates by using CO_2 as a primary factor, and extending to all road vehicle types, a strong carbon price signal is sent to actors purchasing new vehicles. A promising design could be the emulation of the French 'bonus-malus' system; a 'feebate' instrument in which a 'rebate' is offered to purchasers of low-emission vehicles, whilst 'fee' is levied on the purchase of high-emission vehicles (Adamou *et al*, 2014). The evidence suggests such an approach has been effective in reducing the CO_2 intensity of passenger cars sold (D'Haultfoeuille *et al*, 2013). Figure 10 and Figure 11 illustrate the potential effect on the total cost of ownership (TCO) for passenger cars from the use of a Bonus-Malus approach.

Figure 10 - Total Cost of Ownership - Conventional and Alternative-Fuelled Vehicles (Source: Maca *et al*, 2013)

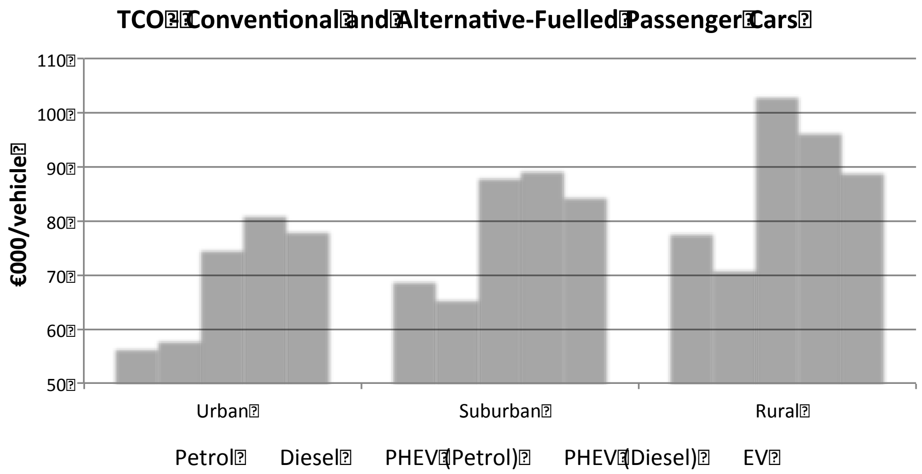


Figure 11 - Total Cost of Ownership - Conventional and Alternative-Fuelled Passenger Vehicles – Bonus-Malus (Source: Maca *et al*, 2013)

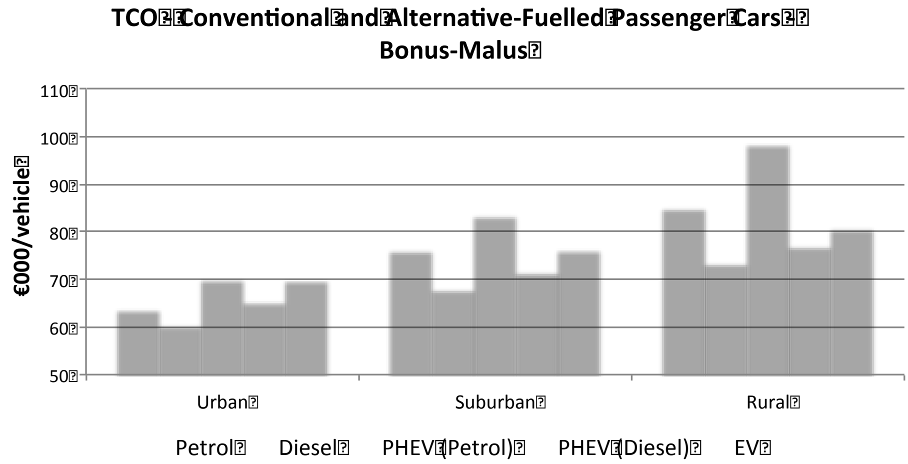


Figure 10 illustrates the TCO of conventional and alternatively fuelled passenger cars, under a given set of assumptions reflecting current price relations and technologies, and no dedicated support schemes.[70] Under these assumptions, low-carbon cars are significantly more expensive than conventional ones. Figure 11 illustrates the change in TCO resulting from the use of a bonus-malus scheme, with the same design as the French instrument[71]. It is immediately clear that low-carbon cars become highly competitive with conventional options on a TCO basis. Such a result may be broadly expected for LGVS and HGVs, depending on the specific design of the instrument (although for HGVs in particular, fuel prices are likely to account for a much higher proportion of TCO than for passenger cars). A feebate instrument may contribute to tackling issues of high capital cost for alternatively fuelled vehicles, in turn reducing the issue of access to and cost of finance, and of private discounting that often acts to hamper the ability of fuel prices to influence vehicle purchase choice (particularly for private passenger cars). Additionally, Member States may design the feebate to be revenue neutral, either entirely (such as in Member States that currently levy no registration tax), or compared to non-zero rates (in Member States that rely on the income generated from existing registration levies) (Drummond, 2015). As such, public acceptability and political feasibility may be considered relatively high for this approach.

As discussed in Section 0, Circulation taxes apply to passenger cars in 24 Member States, and to HGVs in all Member States (although again, with significantly different values). CO_2 is considered a parameter for passenger cars in 18 Member States (and the sole parameter in 6), but not at all in setting rates for HGVs. By setting CO_2 as a primary parameter for circulation taxes for all vehicle types across all Member States, TCO values for new low-carbon vehicles are positively affected, whilst incentives to purchase more efficient second-

[70] Key assumptions include: 14 year vehicle lifespan, no residual value, a 3% discount rate, mileage assumptions of 8,000km/year (urban), 15,000km/year (suburban) and 15,000km/year (rural), and fuel consumption of 96l/1000km for petrol, and 67l/1000km for diesel. See Maca *et al* (2013) for more information.

[71] Pre-2014 values, which range from a €7,000 rebate to a €6,000 fee. Assumptions detailed in Footnote 70 remain the same.

hand vehicles are also increased. This is particularly important in Member States where the second-hand passenger car market is particularly prominent. However, overall, the influence of a CO_2 graded circulation tax is likely to be relatively minor compared to a feebate instrument. Nevertheless, it would likely prove a useful complementary mechanism for including CO_2 intensity in decision-making (Drummond, 2015).

In 2005, the Commission released a legislative proposal that would require Member States to, *inter alia*, restructure both existing registration and circulation taxes for passenger cars (only) to consider CO_2 intensity in their calculation, with the long-term objective of abolishing such taxes. As this proposal was not adopted, it is likely a mandatory approach to achieving the more stringent approach proposed in this policy pathway would be politically infeasible in the short-term. As such, the use of instruments such as the European Semester and other information sharing platforms to encourage this approach may be the most appropriate option immediately available. In the long-term, as road transport becomes increasingly low-carbon and a carbon price on fossil fuels increases, registration and circulation taxes may be abolished from a climate policy perspective.

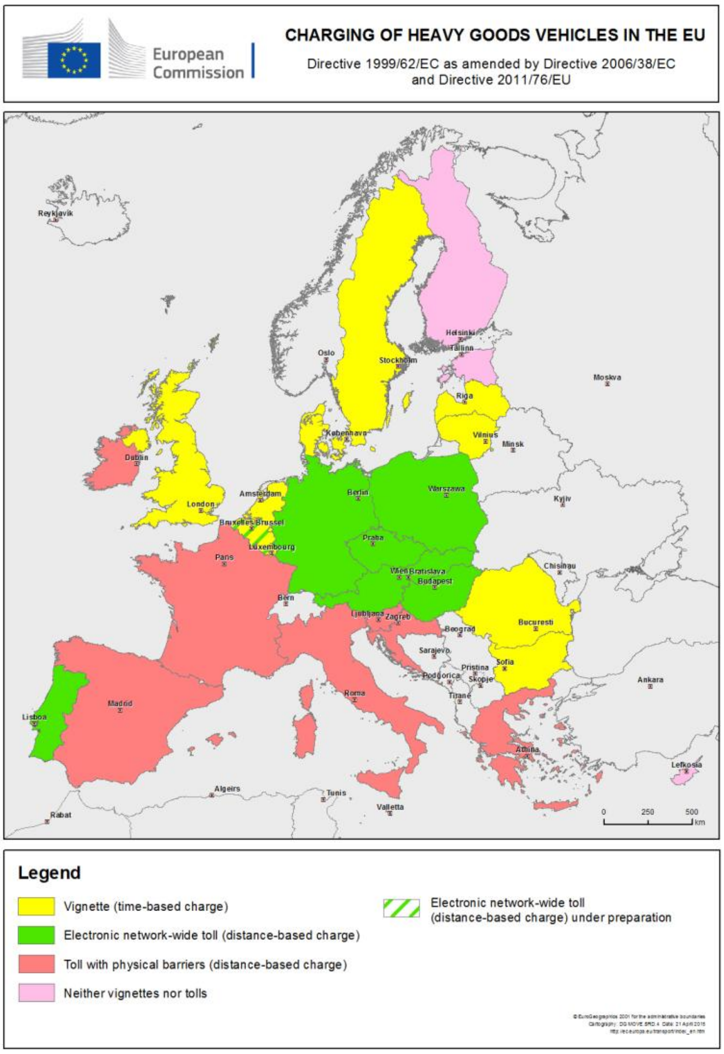
The second option to transmit an appropriate carbon price signal to the road transport sector is the **introduction of CO_2-based road pricing in cities, and EU-wide road pricing for HGVs**. Various city-level road pricing instruments exist around the EU, although the externality (or externalities) targeted varies (e.g. congestion, local air pollutants, CO_2 emissions – or a combination) (Drummond, 2015). The evidence suggest that the most significant impact of these instruments is most often a reduction in the number of passenger vehicles entering the affected zone coupled with a broad modal shift to public transport, rather than a broad shift in average emission intensities (in systems that differentiate by pollutant intensity)[72] (Li and Hensher, 2012). However, Borjesson (2012) found that the exemption experienced by alternative-fuelled vehicles from the Stockholm congestion charge led to a substantial increase in the sales of AFVs (Drummond, 2015). As such, the potential for such instruments to encourage a passenger modal shift for local transport and the purchase of low-carbon vehicles, if applied in cities across the EU, may be substantial. Such instruments may be encouraged though local governance initiatives, such as the CoM (see Section 4.1.1.4), with the revenues raised potentially used to provide and improve infrastructure and stock for low-carbon public and active transport (and/or electric vehicle charging and parking spaces, for example), further facilitating a transition to low-carbon options. 'Efficient' pricing of transport infrastructure is a component of KAP 11 of the Energy Union.

Directive 1999/62/EC[73] sets various framework conditions for the use of distance-related tolls and time-based user charges (vignettes) for the use of certain infrastructure. Where they are implemented, such instruments must, *inter alia*, be levied according to the distance travelled and the type of vehicle (tolls), be levied according to the duration made use of the infrastructure and the vehicle's emission class (vignettes), and include an 'external cost

[72] The evidence is mixed on whether traffic is to some extent displaced to outside of the affected zone.
[73] Modified by Directives 2006/38/EC and 2011/76/EU

charge' to reflect the cost of noise and air pollution (respecting maximum values given by the Directive (European Commission, 2015h). Figure 12 illustrates the Member States that currently employ such instruments.

Figure 12 - Charging of Heavy Goods Vehicles (HGVs) in the EU (Source: European Commission, 2015h)



By making road pricing for HGVs mandatory across all Member States, along with the use of electronic, distance-based levies only for the full network (as already in place in 7 Member States illustrated in Figure 12), and with 'external cost charges' expanded to cover CO_2 emissions, a carbon price signal may be successfully sent to HGV operators. If designed correctly, it could reduce the effects of fuel price differentials between Member States that leads to fuel tourism by this class of road user (however, fuel price differentials may still remain, meaning the issue would not be entirely removed). Such an approach would likely be feasible from both an administrative perspective, as existing physical (and payment) infrastructure may be used, and from a legal perspective, as such charges would be parafiscal in nature (see Footnote 66). Whilst this would thus not require full consensus to implement, it may remain difficult to achieve broad support, given the additional direct cost such an instrument would impose. However, earmarked revenue may be used to provide compensation (at least in the short-term), such as for reduced business levies, additional subsidy or increased rebate for the purchase of low-emission vehicles, or for basic research into further development of such technologies and drivetrains. The use of such an instrument must be well co-ordinated with those above. For example, circulation taxes may be reduced or even removed for HGVs if such road pricing approach is introduced at the appropriate level to influence decision-making and stimulate innovation and/or modal shift.

Each of the elements above seek to send the appropriate price signals to encourage decarbonisation in the road transport sector, and all serve similar but slightly different purposes (e.g. purchase decisions and usage patterns). As such, they may be effectively introduced in parallel in the short-term.

4.3 Policy Pathway Two – 'Technology-Specific'

This policy pathway focuses on regulatory targets and limits, and instruments that encourage particular technologies. Market-based instruments remain a strong feature, and may often be used to accelerate the development or increase the deployment of particular technologies. The role of pricing instruments is secondary in this pathway, and many specific instruments may be removed over time from a climate policy perspective (e.g. vehicle registration and circulation taxes, electric vehicle subsidies, etc.).

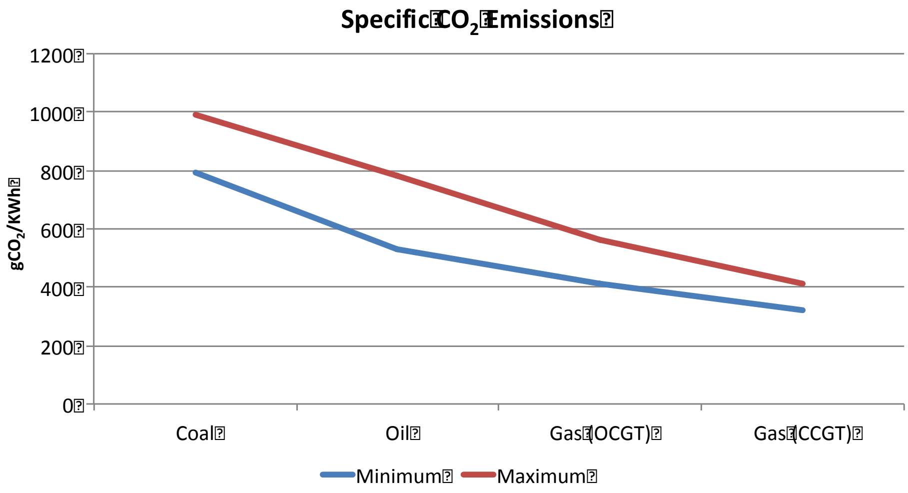
4.3.1 Structural Reform of the EU ETS

Despite the focus of this policy pathway the EU ETS remains a key component, although in contrast to the 'incentive-based' pathway its holds a supporting role to other instruments that more actively seek to drive decarbonisation. Structural reform actions described under Section 4.2.1 for the 'incentive-based' pathway would still prove beneficial, however stringency and extent of such reforms may be reduced such that a lower price is targeted. A similar use of (albeit reduced) auction revenues may also be proposed.

4.3.2 Introduce Power Sector CO_2 Intensity Limit

Under this policy pathway, a principal driver of decarbonisation in the power sector may be the use of a CO_2 intensity limit for new installations, known as an **Emission Performance Standard (EPS)** (although such an instrument may have various labels). A reformed EU ETS, as described above, whilst becoming increasingly redundant in its function for driving decarbonisation, may then act as a 'backstop' to EPS. As described under Section 3.2.1, at a minimum the construction of new unabated coal-fired power stations must be incentivised against or otherwise prevented, to avoid the creation of stranded assets. Figure 13 illustrates the minimum and maximum specific CO_2 emissions for different fossil-generating plants in the EU found in the literature.

Figure 13 - Specific CO_2 Emissions of Power Generation Technologies (Source: Steen, 2001)



According to the values presented in Figure 13, an EPS value of around 600gCO_2/KWh (as an upper value) would be suitable in order to prevent the construction of new unabated coal-fired installations. Both open cycle gas turbines (OCGT) and closed cycle gas turbines (CCGT), along with high efficiency oil installations, would be permitted. However, in practice, only CCGT gas-fired installations are likely to remain a viable option for new non-coal fossil fuel construction, as the levelised cost of electricity (LCOE) for OCGT and (particularly) oil-fired plants are significantly higher than CCGT installations (DECC, 2013), whilst the latter also experiences other restrictions, such as air quality regulation. The EPS value may reduce over time, for example to a maximum of around 350gCO_2/KWh by 2030, to prevent the construction of all but the most efficient CCGT installations (which are likely to maintain a small, but important share of the electricity mix in 2050) (Drummond, 2015), and coal-fired installations equipped with CCS. However, the specific levels required should be subject to further assessment, and are outside the scope of this report.

The introduction and operation of an EPS would be administratively and legally straightforward; similar and more complex regulations already exist for the power sector (e.g. LCPD). The political acceptability of such an instrument is less clear. The European Parliament had sought to amend the proposed text for what became the CCS Directive by replacing the ‘capture readiness’ requirement (Articles 32 and 33) with an EPS set at 500gCO_2/kWh applicable from January 2015. The Commission and Council rejected this amendment, however Article 38 requires the Commission to examine the necessity of an EPS when reviewing the CCS Directive in 2015, although under the condition that CCS is proven safe and economically feasible (Woerdman *et al*, 2015). Whilst this criterion has not been met, the review recommends that the use of an EPS for implementation towards 2030 should be investigated (Triple E *et al*, 2015). The introduction of an EPS must be co-ordinated with the structural reform of the EU ETS, to ensure issues previously experienced (e.g. permit oversupply) are not again induced.

4.3.3 Reform and Extend Minimum Performance Standards and Energy Efficiency Requirements for Buildings

Minimum Standards for New Buildings

As discussed under Section 3.2.3, whilst new residential buildings must be 'nearly zero-energy buildings' by 2020, in practice, energy intensity requirements in most Member States are to be set at 45-50kWh/m^2, with the requirement for the remaining energy consumption to be satisfied 'very significantly' by renewables largely disregarded.

As such, under this policy pathway, **the 'near zero-energy' requirement may be reformed to become a 'net zero-energy' requirement by 2030**. This means that all new residential properties must be a net-zero consumer of energy produced outside the system boundary[74] (based on delivered rather than primary energy) meaning that each building must be able to generate and export as much energy as it consumes from delivered sources, annually (producing zero direct CO_2 emissions). This incentivises building developers to deploy the most cost-effective combination of efficiency measures and renewables, according to local conditions. For example, building developers in southern Member States may deploy solar PV to a higher degree than northern Member States, which may see high levels of energy efficiency as the priority (Drummond, 2015). Whilst such a reform would likely produce little additional administrative burden against existing requirements (except additional monitoring and enforcement efforts, largely required regardless), political acceptability may be difficult to obtain in many Member States. For example the UK recently reduces its ambition for new buildings by removing its Zero Carbon Homes policy (HM Treasury, 2015). The use of best-practice sharing, along with sub-national governance initiatives (e.g. CoM) for those cities or other jurisdictions that have the required regulatory competence, may help to overcome this.

Energy Efficiency Obligation Schemes

Member States are currently obliged to ensure that energy suppliers achieve the equivalent of average annual cumulative savings of 1.5% of total sales, by volume, based on average total sales of the industry across the three-year period leading up to the 1st January 2013. Under this policy pathway, **EEOS could become fully mandatory across Member States, and extended to at least 2030**. As discussed under Section 3.2.3, the majority of energy savings delivered by the existing requirement is likely to be delivered in the buildings (and particularly residential) sector. However, post-2020 the energy saving target may be set exclusively on the residential (or wider buildings sector), to ensure such focus is maintained. The ability to use other forms of compliance, such as payment into a Energy Efficiency National Fund, could also be limited. Further analysis would be required to determine an appropriate annual savings rate to set post-2020.

At present, energy suppliers have flexibility regarding when they introduce measures to achieve compliance with their cumulative obligations between 2014 and 2020 (Drummond,

[74] The site of the individual building or collection of new buildings. This allows for the development of community-level renewable energy installations, including the use of district heating.

2015). Such flexibility, in a restricted form, would remain beneficial with an extended obligation. For example energy suppliers may be able to 'bank' annual overachievement for future compliance, but not 'borrow' from future years for earlier compliance. White certificate systems may also be employed, to encourage cost-efficiency. This, along with imposition of a clear, long-term requirement, may encourage 'deep' retrofits to a greater extent than short-term instruments where overachievement is not incentivised. Additionally, if the energy reduction target post-2020 based on delivered energy rather than simply final energy consumption, it may also encourage the installation of renewable technologies (which the existing formulation does not incentivise) (Drummond, 2015).

For the post-2020 period, it may be of benefit to set sub-targets for achievement. For example, a certain proportion of energy savings must be achieved in low-income households. This may increase the acceptability of this instrument by tackling issues such as fuel poverty (but possibly at the expense of administrative complexity). Existing instruments, such as with the UK's Energy Company Obligation, already take such an approach[75].

4.3.4 Extend Ambition of the Ecodesign Directive

At present, the MEPS introduced by the Ecodesign Directive seek to eliminate the worst'performers from the market (usually in terms of energy consumption). Under this policy pathway, **the Ecodesign Directive may be strengthened to operate in line with the Japanese 'Top Runner' approach, which seeks to 'aim for the best' environmental performance** (Siderius and Nakagami, 2007). In Top Runner, the highest energy efficiency currently available on the market is set as the minimum standard all manufacturers must meet for the weighted average of all their products available on the market by a certain target year (Siderius and Nakagami, 2007). In some cases, the standards are set above the most efficient products on the market to take into account the potential for energy efficiency improvement in the future (Kimura, 2010). Between 1998-2009, 21 technology groups were included across building-related technologies (and transport), with required average energy efficiency improvement rates ranging from 16% to 80%. Each of these targets has been achieved, often relatively easily and with significant overachievement (Kimura, 2010; Siderius and Nakagami, 2007).

By focussing requirements on disseminating the most efficient products rather than on removing the least efficient products, it is likely that a Top Runner approach would be more effective in shifting the market for regulated products to higher average energy efficiency level. A shift to an 'average' approach may also encourage continuous innovation, which is not necessarily induced by the current minimum standards (Drummond, 2013a). The rate at

[75] The Energy Company Obligation 1 (ECO), which runs from 2013-2015, includes three sub-targets. These are a *Carbon Emissions Reduction Obligation,* focussing on domestic solid wall insulation and hard-to-treat cavity wall insulation, a C*arbon Saving Community Obligation,* focussing on providing insulation measures and connections to domestic district heating systems supplying low-income households (15% must be achieved in vulnerable households in rural areas), and a *Home Heating Cost Reduction Obligation,* focussing on low-income and vulnerable households.

which more efficient products are likely to enter use (and thus generate any savings against the counterfactual) is likely to depend on the product in question. For example, building heating systems have a significantly longer average lifetime than a television. As a result, a 'top runner' approach should first focus on long-lived products to reduce the risk of high-energy lock-in. Additionally, a review of the existing product testing methodology, along with proposals for a revised approach may be a appropriate, given the observed differences in efficiency levels between laboratory conditions and real world operation (discussed in Section 3.2.3).

4.3.5 Reform and Extend CO_2 Intensity Regulations for Road Transport

As mentioned in Section 2.1.1, fleet-average CO_2 intensity regulations have been a key driver for reducing the CO_2 intensity of passenger cars in recent years. As discussed in Section 0, such regulations currently apply to passenger cars and LGVs to 2021 and 2020, respectively. Under this policy pathway, such regulations could remain the principal instrument for reducing the CO_2 intensity of the passenger car and LGV fleet with requirements continuing to tighten, and be extended to the HGV fleet. The EU's HGV Strategy adopted in May 2014 envisages legislation to be proposed in 2015 that would require CO_2 emissions from new HGVs to be certified, reported and monitored. Indeed, this is seen as a 'stepping stone' to further measures in the medium-term, of which the most apparent option is such fleet-average regulations (European Commission, 2015i).

For each of these three key transport modes, **fleet-average values could be set for 2025 and 2030 in line with long-term decarbonisation requirements**, to provide clear incentives for investments in innovation to be made in suitable time for resulting developments to reach commercial availability. However, to be truly effective, two further adjustments should be delivered. The first is to **halt the issuance and use of 'super credits' for ULEVs**. With increasingly stringent fleet-average targets, the value this mechanism has reduced, whilst its potential to skew the 'actual' fleet average CO_2 intensity of new vehicles sold increases. The second adjustment is **the adoption and enforcement, as soon as possible, of a new vehicle test procedure to reduce the difference between laboratory and real world conditions**. The new Worldwide harmonised Light vehicles Test Procedure (WLTP) is intended to achieve this when introduced in 2017, however analysis suggests that the differential between laboratory and real world conditions may decrease from around 35% to just 23% under this new regime. As such, options for other approaches should be investigated (such as a comprehensive in-use conformity testing scheme, supplemented by on-road vehicle testing, which evidence suggests may reduce the gap to just 5%) (Stewart *et al*, 2015).

4.4 Cross-cutting Policy Instrumentation Options

Each of the options presented in this section would likely prove beneficial in the short-term (and potentially long-term), regardless of which of the policy pathways presented above is taken. However, it is likely that some options presented may prove more effective or desirable in one pathway or the other. This is highlighted where relevant.

4.4.1 Ensure Renewable Electricity Support and Capacity Mechanisms are 'Sustainable'

Renewable Electricity Support Mechanisms

As discussed in Section 3.2.1, all but one Member State provide financial support for the deployment of renewable electricity. It is likely that such support mechanisms will be required for some time to come, at least until the existing electricity market is restructured to directly incentivise and cater for renewable generation (Held *et al*, 2015). As such, these mechanisms must be cost-effective (particularly to engender public and political acceptability), whilst maintaining investor confidence. A new Renewable Energy Package is expected in 2016-2017 (as part of the Energy Union KAP 13), which must contain provisions to ensure such objectives are achieved.

Guidelines for State Aid for environmental protection and energy 2014-2020 (European Commission, 2014b) require that support for at least 5% of planned new capacity from renewable sources should be granted by a competitive bidding process in 2015-2016, and for all 'large' installations (with an installed capacity of 1MW and over, or 6MW for wind) from January 2017. Such competitive bidding is intended to ensure that support is cost-effective. Support for smaller installations, or for demonstration projects, are exempt from this requirement[76]. **The Commission could regularly assess and disseminate examples of best practice support mechanisms,** for both competitive and non-competitive mechanisms, for as long as such guidance may prove useful. The Commission first produced such guidance in 2013[77]. Based on this guidance, and regular assessments of mechanisms in practice, **the Commission may also propose options for improvement of individual mechanisms**. This could be delivered via, for example, the European Semester process, or a separate mechanism under the Energy Union (discussed under Section 4.1.2.2). This may include encouragement for the introduction of cross-border or aligned support mechanisms, and the increased use of statistical transfers. The introduction of regional targets for RES-E deployment under the Energy Union, discussed under Section 4.1.1.1, may lay the foundations and provide incentives for such action (Held *et al*, 2015).

Although an increase in the use of (potentially cross-border) competitive bidding processes coupled with continued cost reductions in renewable electricity technologies would reduce the cost of delivering RES-E technologies over time (along with reducing average wholesale

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[76] Unless Member States can prove that either (a) only one or a very limited number of projects or sites could be eligible, or (b), a competitive bidding process would lead to higher support levels or low project realisation rates. Additionally, the process may be limited to specific technologies when an open process would lead to a suboptimal result which cannot be addressed in process design in view of the longer-term potential for a given new and innovative technology, the need for diversification, network constraints and grid stability, system (integration) costs, or the need to avoid distortions on the raw material markets from biomass support.

[77] European Commission (2013) *European Commission Guidance for the Design of Renewables Support Schemes*, SWD (2013) 439 final.

electricity prices under the current market design), the cumulative investment required will likely mean total costs will continue to increase into the foreseeable future. At present, the many support mechanisms recover their costs through levies on energy bills (Agnolucci and Drummond, 2014). **Cost recovery could continue via levies on energy bills, meaning that instability and vulnerability inherent in the use of general government budgets may be avoided** (de Rio *et al*, 2015), providing increased confidence for investors in terms of the support available. However, at present, such mechanisms are regressive with the domestic sector bearing much of the burden (with industrial and commercial consumers commonly receiving discounts or exemptions) (Agnolucci and Drummond, 2014). As cumulative costs increase, this issue is likely to become exacerbated. As such, action could be taken to reduce such regressive effects and maintain public and political support for the deployment of RES-E technologies (from a cost perspective).

Three options may be available. The first is the use of additional revenues from the EU ETS (higher than current revenues in both scenarios in the short-term, but significantly so under the 'incentive-based' pathway), earmarked at the EU level for the deployment of renewables and energy efficiency measures, as discussed under Section 4.2.1. This has the benefit both of directly absorbing some of the cost of RES-E deployment and thus avoiding the need to recover it on-bill, and by encouraging energy efficiency exposure to such costs is reduced (particularly under the 'incentive-based' policy pathway, in which an increasing carbon price is levied on residential natural gas). The second option is the use of (increased) EU ETS revenues received by Member States to achieve the same ends, although as these revenues form part of government budgets, they once again become uncertain in the medium-term. The third option is to reduce or remove discounts and exemptions for other sectors, and compensate such interests where required through other means, such as support for efficiency measures, or through **Environmental Tax Reform** principles (e.g. a reduction in labour or other corporate taxation). The extent to which costs may increase and compensation is required depends significantly on the design of the reformed electricity market, and when it is introduced.

Capacity Mechanisms

Although the Commission states that 'capacity mechanisms should only be developed to address security of supply if a regional system adequacy assessment points to such a need' (European Commission, 2015b), as discussed in Section 3.1.2, around half of EU Member States have introduced, or proposed the introduction of, capacity mechanisms to ensure the presence of and investment in adequate capacity to meet future demand. It is likely that capacity mechanisms will indeed be required in the short-term to provide adequate capacity and encourage investment, particularly prior to the introduction of a new electricity market design, and perhaps afterwards.

Capacity mechanisms may be of various designs, but all provide payments to generators in return for bringing a certain level of capacity online when required. However, as with RES-E support mechanisms, misalignment of capacity mechanisms between Member States may cause substantial distortions in an increasingly integrated single electricity market. A single design is unlikely to be appropriate across all Member States (particularly in the short-term), however **cross-border co-ordination for capacity mechanisms is likely to be required**. This might include co-ordinated approaches to the allocation of remuneration of such capacity, and the rights to consume the electricity generated when required (with respect to solidarity principles enshrined in the TFEU) (Henriot *et al*, 2015)[78]. Additionally, **the requirement for such mechanisms to consider the inclusion of demand-side measures may be highly beneficial**[79]. Indeed, the Commission has stated that it will ensure that energy efficiency and demand side response will be able to compete on equal terms with generation capacity in any new electricity market design (European Commission, 2015b).

4.4.2 Reduction and Removal of Market Distortions

Regardless of the policy pathway taken, the reduction and removal of market distortions would be highly beneficial. Under the 'incentive-based' policy pathway, effectiveness of the instrument mix may be greatly increased, as such distortions directly undermine the function of pricing and other market-based instruments. Under the 'technology-specific' pathway, by reducing the relative attractiveness of high-carbon options encouraged by such market distortions, the political and public acceptability of increasingly stringent regulations may be improved.

As discussed in Section 0, rules surrounding company car taxation provide a particularly clear example of such a market distortion (although various other important examples exist). In most Member States, such rules constitute a significant market distortion that substantially dulls the effects of market-based instruments for encouraging CO_2 reduction from the passenger car fleet. In all Member States, a company car is bought by the employer for use by the employee, who declares the vehicle as an in-kind benefit as part of taxable income. How the value of this in-kind benefit value differs (e.g. a proportion of catalogue price, assumed split between business and personal use, or another standard rate). Costs related to insurance, maintenance, repair and other taxes are covered by the employer, but typically not factored in to the calculation of the taxable in-kind benefit. Fuel costs are also commonly covered by the employer, which is often, alongside the costs of maintenance, insurance and other taxes, plus the purchase price of the vehicle itself, VAT deductible. Additionally, as the employee receives the vehicle as an in-kind benefit substituting for a proportion of forgone salary, social security and other related taxes levied on income, which are paid by both the employer and employee, are not due (Maca *et al*, 2013).

As such, the purchase of a company car is financially beneficial to both the employer and employee; with the incentives each is faced with distorted. For example, the employee has

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[78] Within the confines of State Aid guidelines. In April 2015, a sector inquiry was launched to examine in particular whether capacity mechanisms ensure sufficient electricity supply without distorting competition or trade in the EU's Single Market.

[79] For example, in a mechanism that secures capacity via auction, large industrial consumers may bid to reduce their demand by a level equivalent to the additional capacity level required at the time requested, thereby offsetting the need for additional capacity and generation in the first place.

no need to consider the fuel efficiency of the vehicle they are receiving, as they are not bearing the cost of the fuel (which also reduces incentives to reduce vehicle use). Whilst the employer has an incentive to reduce fuel costs (via a more efficient vehicle), it is also incentivised to choose a vehicle with high capital costs, to maximise the benefit of reduced taxation (Drummond, 2015). To reduce the effects such distortions have on new vehicles sold (discussed under section 0), **company car taxation rules could be reformed**. Reforms in both Belgium and the UK may provide lessons on how this may be achieved. In both cases, the taxable proportion of the in-kind benefit is related to the CO_2 intensity of the vehicle (e.g. the higher the CO_2 intensity, the higher the rate of tax levied), and at least part of the fuel received must be declared as taxable income. As such, the employee bears increasing costs for more CO_2 intensive vehicles, reducing their attractiveness as an in-kind benefit (and impacting incentives for vehicle use once purchased) (Copenhagen Economics, 2010). Evidence from the UK suggests that such reforms are effective in reducing CO_2 intensity of company cars, where average CO_2 intensity decreased quicker than passenger cars bought for private use after reforms were introduced (Veitch and Underdown, 2007). It also suggests that the company car market may respond to market conditions faster than the private car market (Maca *et al*, 2013).

Other key market distortions include the regulated electricity prices (discussed in Section 4.1.1.3), and subsidies for fossil fuel extraction. Such reforms may be encouraged by the European Semester process, 'best-practice' sharing, or through legal obligations issued by the Commission where possible. However, the former two options are likely to be the most feasible in the short-term.

4.4.3 Reform Key Existing and Introduction of New Information Instruments

As discussed under Section 2.1.1, informational instruments have thus far had little influence in reducing CO_2 emissions directly or indirectly (e.g. by encouraging the purchase of energy efficient products), due to four broad reasons: (a) low awareness, (b) low understanding of the information presented, (c) ineffective instrument design, and (d) lack of incentives, cognitive complexities and the presence of other priorities. For the key information instruments presented in previous sections, various options are available to reduce some of these barriers and improve their efficacy:

- **Revise the Energy Labelling Directive**. As discussed under Section 3.2.3, the presence of 'A plus' labels, and the grouping of the majority of products into a single efficiency rating reduces the effectiveness of this instrument. As such, **efficiency ratings may be re-graded to A-G, with the range for each value set such that products in the market fall across all bands** (with regular revision). Indeed, the European Commission (2015j) proposed to undertake such reforms in July 2015. Other information, such as expected lifetime energy costs compared to a reference level (e.g. products in the 'C' category), may also prove effective in influencing purchase decisions.

- **Standardise EPC format and calculation methodology**. A standardised approach to calculation methodologies for EPCs, along with an increased standardisation of their design (along current best-practice approaches), may reduce increase the ability of EPCs to be effective in providing accurate, relevant and understandable information to consumers, and allow comparisons between Member States.
- **Strengthen requirements for energy billing information provision**. Current requirements for the provision of information on the energy consumption of households of a similar profile, and information on where to seek information on energy efficiency (as described under Section 3.2.3), may be boosted by the provision of more 'direct' information on efficiency options. For example, cost-saving estimates for switching off appliances rather than using a 'standby' mode, or the use of more efficient lamps, may encourage such actions to be taken.
- **Revise and standardise Car Labelling Directive requirements**. As described under Section 0, the Car Labelling Directive has had little influence thus far. This may increase with standardisation of the labels provided (with 'best-practice' design), including the provision of more salient information, such as expected fuel cost savings over the lifetime of the vehicle.

Whether the above options are implemented as mandatory requirements or are simply encouraged by processes such as the European Semester or other 'best-practice' information sharing for a depends both on whether or not the option must be implemented centrally (e.g. energy labelling classifications), and political feasibility.

Whilst such options are likely to be beneficial regardless of the instrumentation direction taken, it is likely that their importance would increase under the 'incentive-based' policy pathway. Other actions presented for the 'incentive-based' pathway (under Section 4.2) seek to tackle point (d) above, and alter the incentive framework (and alter priorities) such that more cost-effective action can be taken, and thus information instruments have a more significant role to play. Under the 'technology-specific' pathway, such options are reduced (although choices remain present), diminishing the potential role of such instruments in driving decarbonisation (in the long-term, in particular). However, by overcoming information failures and asymmetries and increasing demand for energy efficient products (for example), the public acceptability of instruments proposed under the 'technology-specific' pathway may increase, as they may appear less stringent than may otherwise have been the case.

There is much more that information instruments can do to encourage consumers to make smarter choices. Below are two key examples.

'Farm to Fork' GHG Accounting System

The evidence suggests that to be truly effective, any instrument mix that seeks to tackle emissions from the food and agriculture sector must consider the full supply chain in an integrated manner. Otherwise, a piecemeal approach may emerge in which important (direct or indirect) abatement options may not be induced or incentivised (Kuik and Kalfagianni, 2013). A sensible first step towards such a holistic approach would be to **investigate the**

potential for a common 'farm to 'fork' GHG accounting system for the key foodstuffs (particularly meat products). Some Member States have, or are in the process of, developing such accounts on an experimental basis (e.g. the UK and Netherlands). The development of a common approach may be lead by the EU's statistical office, EUROSTAT.

Such an instrument would allow for the identification of key areas to tackle, and in the medium to long-term, lay robust foundations for policy instruments that make use of this information. Examples would include GHG labelling or fiscal incentives (such as a tax), to encourage consumers to select products or brands with a lower GHG footprint (including a move away from meat, and a move towards locally produced foodstuffs). Further research is required to determine what the particular boundaries of such an accounting system may be, and how it may sit alongside other instruments (e.g. LULUCF accounting methodologies). Other instruments to ensure issues such as food waste must also be considered (including, for example, a potential tightening of the biodegradable waste provisions in the Landfill Directive).

'Soft' Transport Measures

'Soft' transport policy measures aim to directly influence decision making by altering perceptions of the objective environment, by altering judgements of the consequences associated with different travel alternatives, and by motivating and empowering individuals to switch to alternative travel options (Bamberg *et al*, 2011). Many instruments and initiatives may fall under this definition, although 'Personalised Travel Planning' (PTP), which provides information, incentives and motivation tailored to the individual, rather than through general mass marketing methods (Ker, 2003), holds particular promise - especially for shifting passenger travel from cars to other modes (the primary aim of most existing or historic PTP instruments) (Cairns *et al*, 2004). As such, **introducing 'soft' transport measures, particularly PTP in large urban areas and key commuter regions, may encourage modal shift in passenger transport** to lower-carbon alternatives (if such options are available, or made available). This may be voluntarily introduced, for example, through mechanisms such as the CoM.

PTP instruments have been extensively trialled across the world. A review of PTPs in several cities across the world calculated that these instruments produced a reduction in car use of between 2% and 15% (DETRA, 2004). In London, four PTP pilots reduced car usage by 5%-11% (Transport for London, 2004). A meta-analysis of the effectiveness of 10 PTP instrument across four cities in Japan determined that an 18% reduction in car use was produced, along with a 50% increase in public transport, producing a 19% reduction in CO_2 emissions (Fujii and Taniguchi, 2006). Based on a review of 32 PTP programs in Sweden Friman *et al* (2013) conclude that positive effects are on a par with the results observed in other countries. In 7 of these programs, which focussed on car users, the reduction in the number of car trips is 22%. On average, these programs led to an increase in the number of bus trips by 36% (ranging between 2% and 93%). Two programs that aimed at increasing bicycle use report an average increase of 43 % in bicycle trips (Drummond, 2015). The evidence is generally positive that the effects generated by PTP instrument are maintained beyond the timeframe of the instrument, although further longitudinal studies are required to produce evidence for truly long-term impacts (Maca *et al*, 2013).

5 Discussion

5.1 Addressing Short-Term Requirements

As described in Section 2.2.2, a successful climate policy instrument mix must address all three 'pillars of policy'; 'standards and engagement', 'markets and pricing', and 'strategic investment'. The options presented in the report ensure that this is achieved, with existing issues corrected where possible, and gaps in instrumentation filled where required. Two possible configurations are presented; the 'incentive-based' pathway, in which the 'markets and pricing' pillar is key, and the 'technology-specific' pathway, in which the 'standards and engagement' pillars are the focus. Instrumentation options that would likely prove beneficial, alongside reform of framework conditions to facilitate effective operation of instruments across all three pillars of policy, both individually and in combination, regardless of the policy pathway pursued, are also presented.

The **standards and engagement** pillar is emphasised under the 'technology-specific pathway through the tightening and improvement of existing standards and regulations (e.g. a power sector Emission Performance Standard, CO_2 intensity of vehicles regulations, a reformed Ecodesign Directive, etc.). Whilst such instruments remain largely untouched under the 'incentive-based' approach in the short-term (in order to act as 'backstop' instruments), but become increasingly redundant over time (with no reforms instituted, and those with time or other limitations expiring after their obligations are met), regulations to overcome the landlord-tenant dilemma, for example, are kept. The reform of existing and introduction of new information instruments and the review and dissemination of best-practice policy approaches, for example, is proposed as applicable to both policy pathways. The **markets and pricing** pillar is emphasised under the 'incentive-based' policy pathway through the reform and expansion of the EU ETS, and the use of pricing instruments in remaining sectors to drive the low-carbon transformation. Under the 'technology-specific' pathway, the EU ETS is again reformed, but to a less ambitious extent, and retains its existing sectoral coverage. Market-based instruments, or market-based elements, remain important. Under both pathways, the reduction and removal of market distortions is encouraged. The **strategic investment** pillar receives substantial attention in both pathways through, for example, the reform of RES-E support and capacity mechanisms, the provision of funding for innovation and other low-carbon infrastructure (from various source), the production of long-term infrastructure plans and the 'mainstreaming' of low-carbon development (through, for example, the use of a social cost of carbon in decision making).

The two subsections below discuss how each of the ten challenges discussed in Section 3 are achieved or overcome. As the interrelation between these challenges, and between the instrumentation and reform option in this report are complex and nuanced, only key points are raised to maintain clarity.

5.1.1 'Systemic' Challenges

- **Establish a Meaningful Carbon Price.** Under both policy pathways, a revised and strengthened EU ETS remains the primary instrument for delivering a carbon price. Price control mechanisms are introduced, and carbon leakage measures are reformed to ensure industry sectors (and downstream consumers) are fully subject to a carbon price. Under the 'incentive-based' pathway, such revisions are more stringent to produce a carbon price of suitable levels to drive the low-carbon transition (and a clear indication of increasing prices of relatively high predictability into the future), including a scope extended to the domestic heating sector. For (road) transport under the 'incentive-based' pathway, a carbon price is instituted not through direct pricing of fuel, but through CO_2-based registration and circulation taxes, and road pricing. Under the 'technology-specific' pathway, carbon pricing acts primarily as a complement and 'backstop' to regulatory instruments, which act to drive decarbonisation. Under both policy pathways, reforms such as revised company car taxation rules and the phasing out of regulated energy prices are introduced to ensure carbon price signals are transmitted to end-users, whilst instruments such as CO_2 labelling of cars and corporate GHG reporting help to encourage such signals to be acted upon.
- **Complete the EU-Wide Electricity Market Reform and System Integration.** Barriers to the deployment of appropriate grid infrastructure are reduced through streamlined and clear planning and authorisation procedures, and the continued provision of central EU funds for the construction of key sub- and inter-state infrastructure. Integrated, multi-state long-term planning procedures and incentives help to reduce administrative and political barriers, and the potential for unintended consequences. Two primary options for electricity market design are presented, 'Melting Pot' and 'Salad Bowl'. The former, which applies an equalised, technology-neutral market mechanism for all generating sources, is clearly aligned with the 'incentive-based' approach, whilst the latter, which applies differentiated market rules based on different types of generator, is clearly aligned with the 'technology-specific' approach. Regardless of which approach (and policy pathway) chosen, a full implementation of the Third Energy Package facilitates the creating of a fully integrated single market. Additional options, such as the introduction of mandatory minimum technical standards for smart meters to facilitate demand-side response (in particular), also contribute.
- **Make Sound Infrastructure Choices Despite Technological Uncertainty.** The production of long-term infrastructure plans (potentially produced by National Infrastructure Authorities, and municipal-level counterparts), will help to highlight such uncertainties, along with conflicts and synergies of such plans both within and between Member States. Such plans may be central to a 'technology-specific' approach, in which the regulator takes a leading role in technology selection, but of substantially reduced scope in the 'incentive-based' pathway, where the role of technology selection is left (largely) the role

of the market. Under both pathways the 'mainstreaming' the low-carbon objective, including through the use of a social cost of carbon in planning decisions, and revised operating rules and guidelines for public financial institutions and other investments help, at a minimum, to prevent the creation of what may become stranded assets. Corporate information disclosure also encourages such organisations to consider long-term developments, and reduce high-carbon activities and investments.

- **Provide Finance and Mobilise the Investments Necessary for a Low-Carbon Economy.** The strengthening of carbon pricing (under both policy pathways), along with the reduction and removal of market distortions, helps to align the incentives for investment in low-carbon over high-carbon assets in the first place. A review and alignment of rules governing financial markets to ensure they are compatible with the long-term financing required for low-carbon infrastructure, along with the provision of institutions, funds and financial instruments (at the EU and national level) with a mandate to invest in low-carbon infrastructure and assets, helps unlock substantial private sector capital. Additional revenue earmarked from the EU ETS for the deployment of renewables and energy efficiency, and to encourage innovation in the power and industry sectors may also be important. Information instruments, such as corporate disclosure of GHG emissions and high-carbon assets, along with instruments aimed directly at consumers, enables improved risk assessment, and encourages a shift to lower-carbon investments and assets. 'Smarter' policy design (discussed in Section 6, below), aided by the dissemination of 'best-practice' approaches, helps provide long-term confidence in the instrument mix, and guards against abrupt changes as far as possible.
- **Encourage Low-Carbon Lifestyles.** As with unlocking the appropriate finance, the first policy-relevant steps in encouraging the emergence of low-carbon lifestyles is to ensure the economic incentives are appropriate, the choices available exclude particularly high-carbon options, and low-carbon options are easily attainable. Carbon pricing in the 'incentive-based' pathway and regulatory requirements in the 'technology-specific' pathway contribute to the first two points. Under both approaches the use of streamlined and integrated spatial planning help to achieve the third, in particular. All three points are supported by the provision of information in order to influence the decisions of citizens as consumers (e.g. 'nudging' and PTP instrument) and as investors (discussed above).

5.1.2 'Sectoral' Challenges

- **'Fully' Decarbonise the Power Sector.** Under the 'incentive-based' policy pathway, a strong, more resilient EU ETS primarily drives this through shifting the merit-order in the short-term, and sending a long-term carbon price signal for new investments. Whilst a reformed EU ETS remains a key driver in the 'technology-specific' pathway, an increasingly stringent Emission Performance Standard prevents construction of new high-carbon capacity (particularly unabated coal). Under both approaches, RES-E support mechanisms remain vital in the short-term (and are revised to be more effective and cost-efficient where required), along with a facilitating electricity market and interconnected grid (discussed above). Non-binding renewables targets, perhaps instituted by the Energy

Union process and with earmarked EU ETS revenue to incentivise (over)achievement, may encourage appropriate ambition political commitment.

- **Facilitate Low-Carbon Transport.** Under the 'Incentive-Based' pathway, CO_2-based registration and circulation taxes, along with road pricing, encourage a shift to low-carbon drivetrains for road vehicles, and a shift to modes with a lower-CO_2 intensity. Under the 'technology-specific' pathway, a shift to low carbon vehicles is driven by strengthened and expanded CO_2 intensity regulations. However, various other options presented support these instruments. From a governance perspective, integrated spatial planning processes and the production of long-term infrastructure planning (at the national, supranational and perhaps municipal level), identify and facilitate the required infrastructure. Initiatives such as the CoM encourage low-carbon solutions (e.g. active or public transport) where transport emissions are particularly concentrated. GPP criteria and requirements may support this by enabling the deployment of ultra-low public transport vehicles (e.g. electric or hydrogen bus fleets). The removal of market distortions (e.g. company car taxation rules) and the provision of information (e.g. personalised transport planning), seek to alter consumer choices to low-carbon options
- **Tackle the Energy Consumption of the Housing Stock.** The expansion of the EU ETS to natural gas in the residential sector, supported by subsidy instruments for the deployment of energy efficiency and renewable (heating and cooling) technologies (possibly funded by additional EU ETS revenue), are the primary drivers for energy efficiency and decarbonisation of the housing stock. Whilst existing near-zero energy requirements for new buildings and energy efficiency obligation requirements for existing buildings remain in this policy pathway, in the 'technology-specific' option, such instruments are strengthened and expanded, and become the primary driver of energy efficiency and low-carbon technologies - supported by an Ecodesign Directive of substantially increased ambition. Under both pathways, increased monitoring and enforcement action ensures practical compliance with these Directives. Information instruments and instruments such as 'nudging', a revised energy labeling directive and the continued deployment of smart meters (with minimum technical standards) encourage individuals to adopt cost-effective measures and behaviours, and to close the 'energy efficiency gap'. For instruments and approaches not standardized at the EU level, 'best-practice' sharing platforms encourage effective and cost-effective designs.
- **Stimulate Radical Low-Carbon Innovation in Industry.** Under both policy pathways, a revision of carbon leakage measures under the EU ETS (including definition of sectors at risk) reduces the insulation from carbon price signals the industry sector currently experiences (whilst maintaining temporary protection for industries that require it). This is expected to encourage adoption of existing technologies that may have not previously been incentivised, and to raise the necessity for investment in innovative technologies and for their deployment in the long-term. This would be particularly the case under the 'incentive-based' pathway, with a much-enhanced, credible and predictable carbon price. Under the 'technology-specific' pathway, innovation may be driven my increasingly stringent Ecodesign requirements, supported by carbon pricing. Both approaches may be

supported by corporate disclosure guidelines/requirements. To reduce market failures associated with innovation, regular assessments of technological options and developments (via a revised SET-Plan), along with increased EU level funding (from various sources including EFSI, Cohesion Policy Funds, the EIB and the 'Innovation Fund' under the EU ETS – particularly enhanced under the 'incentive-based' pathway, with substantial additional revenue) and national sources (including public financial institutions) support initiative under the Innovation Union.

- **Address non-CO_2 Greenhouse Gas Emissions, Particularly from Agriculture.** Under both policy pathways, the first step in addressing this challenge is to investigate options for a 'farm to fork' GHG accounting system. This prepares the ground for the introduction of well-targeted instruments, such as fiscal incentives, regulatory or information instruments in the future, to tackle emissions where the priority and opportunity is greatest. However, various institutional reforms also contribute to the abatement of non-CO_2 GHGs in the short-term. For example, the 'mainstreaming' of the low-carbon objectives ensures that non-climate instruments, that have historically been the (policy induced) drivers of abatement in the agriculture sector, continue to contribute. Increased monitoring and enforcement action also aligns with this objective (such as ensuring cross-compliance under the CAP). From a strategic 'framework' perspective, maintaining emissions from agricultural activities under the ESD, rather than establishing a 'LULUCF + agriculture' pillar under the 2030 Climate and Energy Framework, retains a long-term abatement incentive and avoids the possibility of meeting obligations using other, often problematic LULUCF actions.

5.2 How 'Optimal' are these Options?

Much existing policy analysis, particularly when conducted from an economic standpoint, focuses largely on static efficiency (defined below), which often leads directly to the recommended implementation of pricing instruments alone as the cost-minimising solution (Görlach, 2013). Such an approach is simplistic and neglects many 'real world' issues that limit the effectiveness, including various market failures that prevent the transmission of the price signal and the ability or willingness of market actors to respond to it (split incentives, environmentally harmful subsidies, information asymmetries, etc.), legal compatibility, administrative burden, and political and public acceptability. As such, the CECILIA2050 project employs a broader definition of 'optimality' that considers three criteria against which a policy mix may be applied (Görlach, 2013):

- **Effectiveness** – Are the policy instruments, and the instrument mix overall, achieving their/its objective(s)? Whilst the overall objective of the instrument mix is to drive GHG mitigation, individual instruments may have varied objectives (e.g. information provision, deployment of renewables, etc.), against which their effectiveness must be measured.
- **Cost-effectiveness** – This criterion holds two components. The first is **static cost-efficiency**, which implies that an instrument or instrument mix achieves its objectives at least cost, given currently available abatement options. The second is **dynamic cost-**

efficiency, which concerns the delivery of abatement at least cost over a given time period, by incentivising the continual development and implementation of low-carbon technologies and behaviours.

- **Feasibility** – Does the instrument or instrument mix match with practical considerations? This includes various components, including **administrative burden** (including ease of administration, transaction costs for compliance and enforcement, etc.), **legal and institutional feasibility** (compatibility with existing legal frameworks, institutional culture and capacity, etc.), **political and public acceptability** (likelihood of political support and acceptance by the public, including equity and distributional concerns), and **flexibility** (ability to risks and uncertainties of the effects of the instrument or instrument mix itself, or to exogenous developments).

These criteria have some clear inter-relations and trade-offs, and are a mix of (potentially) quantifiable and fully qualitative criteria. They may also be applied to individual instruments, collections of instruments, or the instrument mix as a whole. They may also be applied at different spatial scales (e.g. all-EU, or individual Member States). See Görlach (2013) for a full discussion of this extended definition of 'optimality'. In the three sub-sections below, the proposed instrument mix (and institutional reforms) is taken as a whole, and examined largely at the EU level.

5.2.1 Effectiveness

The 'incentive-based' policy pathway employs ideally technology-neutral pricing and other incentivising instruments to encourage a market-driven shift to low-carbon investments, technologies and behaviours. The primary instrument is a reformed and expanded EU ETS. As a cap-and-trade instrument, the maximum level of (mainly CO_2) emissions from the covered sectors (power, industry and now residential heating) is known *ex ante*, with environmental effectiveness guaranteed[80]. However, this is not the case in the remaining non-ETS sectors (e.g. the use of CO_2-based regulation and circulation taxes, and road pricing in the transport sector). Additionally, in both cases, the specific technologies deployed and behaviours adopted (or in the case of the ETS sectors, the division of abatement between sectors), is left to the market. Such uncertainty, which may produce increased difficultly for planning and ensuring co-ordination of interdependent abatement efforts, is a trade-off for improved cost-efficiency, as discussed below. Reducing and overcoming both market distortions and information failures is important in exposing market actors to price signals, and allowing them to respond to these signals, and thus contributing to the effectiveness of the 'incentive-based' pathway. The first is delivered, for example, through reforming of company car taxation rules and the phasing out of regulated electricity prices. The second is delivered through the reformation of key existing information instruments (such as the Energy Labelling Directive and Energy Performance Certificate formats and calculation methodologies), alongside the introduction and promotion of new instruments (such as 'soft'

[80] Assuming adequate monitoring and enforcement into the future, the adequate prevention of fraudulent activities, and the prevention of the use of international credits with unclear credibility for compliance.

transport measures and corporate reporting requirements). Such instruments and reforms may variously be implemented or encouraged through mandatory requirements, direct recommendation (e.g. via the European Semester process), or other initiatives, such as the CoM.

Although pricing and other 'incentive-based' instruments are the driver of change in this pathway, the existing complement of regulatory instruments, with their associated requirements and targets, should remain in the short-term. Those with standing obligations, such as minimum energy performance standards for buildings, may act as a regulatory 'backstop' to pricing instruments. Instruments with time-limited obligations, such as energy efficiency obligation schemes, may expire once met, and not be renewed. However, this particular example must be balanced against the requirement to tackle the landlord tenant dilemma – principal instruments for which are continued energy efficiency obligations, or (increasing) minimum energy performance standards for rented properties. Such an approach has two key benefits. Firstly, it allows time for the principal instruments in the 'incentive-based' pathway to become established and strengthened. Secondly, it maintains stability and reduces the administrative burden (and possible political discord) associated with the (early) termination of such instruments.

The 'technology-specific' policy pathway employs regulatory targets and requirements as the primary drivers for decarbonisation, with pricing instruments providing a largely supporting role. Whilst a reformed EU ETS remains important (but with reforms less significant, including maintaining existing sectoral scope), in the power sector decarbonisation is driven by an Emission Performance Standard for new installations, preventing the construction of new, highly CO_2-intensive capacity (e.g. unabated coal). In other sectors, largely existing instruments are improved, extended and tightened. In the (residential) buildings sector, 'near-zero' energy requirements for new builds become 'net-zero', whilst the requirement for energy efficiency obligation schemes for existing buildings are extended beyond 2020. These instruments are supported by an Ecodesign Directive with a significantly increased ambition. In the transport sector, fleet-average CO_2 intensity regulations are expanded from cars and LGVs to HGVs, with targets set beyond the early 2020s (as currently set for cars and LGVs). The practical operation of these instruments is also reformed, where required. This includes improved monitoring and compliance mechanisms, and a reduction in the ability to demonstrate compliance with the use of alternative mechanisms (where such options detract from the direct objective of the instrument). The increased application of monitoring and enforcement mechanisms may also ensure compliance with regulatory requirements (including those concerning information instruments and aspects such as full, accurate and timely reporting). This policy pathway allows for more direction over how the low-carbon transition is achieved compared to the 'incentive-based' pathway, but with potentially reduced cost-efficiency (discussed below).

In both pathways, design elements and processes to enhance the ability of the instrument mix to respond to and deal with risks and uncertainties buttresses the effectiveness of the climate policy mix into the longer-term, providing stability. Such elements and processes are discussed under ‘Feasibility’ (Section 0, below).

5.2.2 Cost-Effectiveness

Under the ‘incentive-based’ pathway, by expanding the reach of the (strengthened) EU ETS and thus an equalised marginal abatement cost, the static cost-efficiency of the instrument mix is increased (both against the existing complement of instruments, and against the ‘technology-specific’ pathway). This is supported by the use of instruments to tackle information failures and the reduction and removal or market distortions (to align incentives and increase the desire to respond to them), and by the reduction of financial and administrative barriers (facilitating such responses). Whilst the ‘technology-specific’ pathway relies mainly upon regulatory instruments, producing varied implicit marginal abatement costs, it is likely that the static cost-efficiency of this pathway is improved against the existing EU climate policy mix. Although the design and configuration of the ‘technology-specific’ pathway is similar to the status quo (including sectoral coverage of the EU ETS, and the possibility to employ market-based instrument or elements to achieve regulatory goals), improvements to the functioning of individual instruments (such as revised carbon leakage measures under the EU ETS, more effective compliance test mechanisms and the sharing of ‘best-practice’ instrument designs across Member States), coupled with the reduction of market distortions and removal of other barriers, as discussed above, would likely reduce the marginal abatement costs against a case in which the targets and requirements of existing instruments were simply extended.

By providing an extended carbon price signal that recipients constantly seek to minimise (through the EU ETS, in particular), theory would suggest that the ‘incentive-based’ policy pathway would be the most dynamically cost-efficient of the two pathways. However, for this to be the case, market actors must have confidence in the future presence and magnitude of such liability, which the EU ETS has thus far largely failed to provide (Drummond, 2013a). Whilst the various reforms to the EU ETS (in particular) proposed above (for both policy pathways) should substantially improve this situation, the (relative) regulatory certainty provided by the instruments under the ‘technology-specific’ pathway (including increased clarify regarding specific sectoral and sub-sectoral contributions, specific targets and the timeframe in which they must be achieve), provides a clear incentive to develop and deploy technologies with ever-reducing marginal abatement costs. Whilst under a regulatory instrument a dynamic incentive is broadly not provided, as there is little motivation to exceed the requirements set, establishing long-term requirements or targets of increasing stringency significantly diminishes this argument. However, by it’s very nature the ‘technology-specific’ pathway holds an inherent element of ‘picking winners’ by government, which may not induce deployment of the most cost-effective technological options. In some sectors, such as industry, there remains substantial uncertainty regarding technological development and therefore the most cost-effective technologies for regulation to promote. This may in turn induce regulatory uncertainty, if the favoured technology (or set of technologies) do not deliver the expected abatement, does not mature or reduce in cost at expected rates, or are otherwise unpopular.

Irrespective of the pathway chosen, the dynamic cost-efficiency of the instrument mix is likely to be increased against the status quo. This is supported by the measures introduced to overcome market failures associated with innovation, such as frequent review and prioritisation of key technologies, the provision of dedicated funding for the development of innovative technologies (from various sources, both EU and Member State level) and enhanced Green Public Procurement criteria. Frequent review of technologies (through a revised SET-Plan procedure) also allows for clarity on the division between and level of support for innovation and for deployment, allowing for effective targeting and a reduced risk of over-subsidisation.

At a macroeconomic level, modelling evidence suggests that substantive action taken to decarbonise the economy, driven by the options and pathways presented in this report, would have a substantially positive impact on GDP growth in the EU (particularly in the short term). This is driven particularly through investments in renewables, electricity grids and energy efficiency **(**Meyer *et al*, 2014), the latter of which, as discussed above, exhibits significant cost-negative opportunities for energy and emission reductions. Additionally, such investments may substantially increase the international competitiveness of the renewables industries, potentially stimulating first-mover advantages (Antimiani *et al*, 2015).

In order to minimise the total costs of decarbonisation, the risk of creating stranded assets must be minimised. The options presented in this report, under both pathways, including (a) long-term instrumentation clarity and confidence, including carbon prices and regulatory requirements, (b) long-term planning to reduce the risk of incompatible choices, (c) 'mainstreaming' of low-carbon objectives in governance, policy making and public investments and financial institutions, and (d) corporate reporting and disclosure of GHG emissions, high-carbon assets and risk assessment procedures, help to reduce these risks. However, stranded assets remain a possibility regardless of the pathway chosen, although present through different mechanisms. In the 'incentive-based' pathway, the free choice of actors responding to price signals may include investment in assets that become uneconomic. Whilst the 'technology-specific' pathway would at first seem less likely to lead to the creation of stranded assets, the promotion of what may turn out to be a relatively high-cost technologies may produce the same effect.

5.2.3 Feasibility

The options and policy pathways presented are likely to produce and necessitate relatively substantial changes to existing administrative requirements. Initially, significant effort may be required in order to establish the governance structures, procedures and instrument reforms proposed (under each pathway). At the EU level, a potentially enhanced role for DG CLIMA (in terms of ensuring 'mainstreaming' of low-carbon objectives, collating and disseminating best-practice guidance, and increased monitoring and enforcement action), for example, may increase administrative requirements in the longer-term, regardless of the policy pathway chosen. This is likely a key trade-off required to buttress the effectiveness of the instrument mix. Whether the administrative burden is increased at the Member State level in the longer-term depends on existing structures and processes. However, it is reasonable to suggest that the 'incentive-based' pathway, with its promotion of pricing and other incentivising instruments (including a potential shift of EU ETS compliance upstream) would infer less of an administrative burden (at all levels) than the 'technology-specific' pathway, with its various, differentiated and specific requirements.

Many options presented are likely to reduce administrative burden in the longer-term, for public authorities at all levels, and for other market actors (from industrial sector to individuals). Examples include the collation and clarity of administrative responsibilities, long-term planning and reporting mechanisms for public authorities (Member States in particular), and the simplification and standardisation of compliance, monitoring and reporting requirements and guidance (where appropriate) for individual instruments.

All options presented in this report are possible within the existing overarching legal framework of the EU, although many would require the introduction of new or amendments to existing Directives or Regulations to introduce, and subsequent transposition into Member State law. A particular example of common concern is the legal compatibility of alternative carbon leakage measures under the EU ETS. As discussed in Section 4.2.1, the introduction of output-based permit allocation with consumption-based charges avoids questions of WTO compatibility, and as the latter component is a parafiscal charge, may be introduced by qualified majority in the European Council, rather than unanimity.

Acceptance by the public, industry and other societal actors is often critical in obtaining political feasibility. The industry acceptability of the proposed revised carbon leakage measures is difficult to ascertain, although the combination of OBA, using frequently updated production data against a 'best available technology' benchmark, with CO_2-based consumption charges, is likely to be one of the more acceptable options available. Free allocation remains, whilst allocation of such allowances against frequently updated benchmarks, reducing windfall rents, is a measure already proposed by the Commission. This relative increase is costs may be tempered in the medium- to long-term by an increase in the provision of funding for innovation in the industry sector (from various sources, including the 'Innovation Fund' under the EU ETS). The downstream CO_2 consumption charge may induce a reduction in demand for such products (varied by sub-sector, depending on specific demand elasticities and the availability of substitutes) in the short- to medium-term, before less-CO_2 intensive options are developed. However, as many industrial products are fed into other products or processes (steel, cement, etc.), such charges are incorporated into the price of the final consumer product, and are not therefore explicitly visible to the public. Additionally, the marginal price increase of an individual end-user product may be negligible (at least in the short- to medium-term). Such aspects likely render such a charge broadly acceptable by the general public. From a broader perspective, the long-term clarity and stability of such revised rules, and of the EU ETS (and instrument mix) more widely, is essential in allowing for long-term planning and investment (Neuhoff *et al*, 2014b), and likely raises the acceptability of these options to the industrial sector independently of their specific design. Such an effect is likely to be present beyond the industrial (EU ETS) sectors (e.g. vehicle manufacturers).

The proposed instrument mixes and reform options exhibit many features that seek to maximise public acceptability. A principal issue is that of increasing cost to the consumer resulting from the instrument mix, either directly (for example, though inclusion of residential natural gas under a strengthened EU ETS), or indirectly (for example, through higher cost products, or levies on energy bills to allow cost-recovery of renewable support mechanisms). More intelligent instrument designs, such as market-responsive RES-E support mechanisms, and the use of other flexibility mechanisms (discussed below), helps to minimise such costs in the first place (across both policy pathways). The additional use of central EU funding for the deployment of renewables, energy efficiency and transmission infrastructure further reduces the impact of (often regressive) on-bill cost recovery. Whilst the deployment of energy efficiency measures (particularly in the residential sector) further counters the effects of remaining costs, careful instrument design (such as the use of sub-targets under an extended energy efficiency obligation schemes under the 'technology-specific' pathway), may encourage an equitable, progressive and more publically acceptable outcome (Zvěřinová *et al*, 2013). Improved and expanded information instruments highlight cost-effective (or net cost-negative) products and behaviours of which consumers may previously been unaware, allowing for further cost savings. This is particularly the case if low-cost options that may have previously been unavailable, such as active transport infrastructure, are made available (e.g. through integrated spatial planning). In turn, these measures, coupled with the reduction and removal of key market distortions, may increase the public acceptability of increasingly stringent instruments that may have been previously considered untenable. For example, by removing the market distortion for company cars currently experienced in many Member States (and thus reducing demand for highly CO_2-intensive cars), and providing alternatives such as low-cost (and low-carbon) active and public transport, the public acceptability of CO_2-based road pricing in cities (under the 'incentive-based' pathway) or increasingly stringent fleet-average CO_2 regulations for vehicles (both of which might be expected to increase the cost of purchasing and driving a vehicle[81]), is likely to increase. However removing such a distortion, which currently benefits employees, employers and the manufacturers of CO_2-intensive vehicles, is likely to prove politically difficult in many Member States.

Aside from the actual or perceived impacts of proposed instruments and instrument mixes, other elements act to enhance public acceptability. For example, evidence suggests that the earmarking of revenue raised from pricing instruments (or the removal of market distortions) increases public support for an instrument or instrument mix (Zvěřinová *et al*, 2013). Increased earmarking of EU ETS revenues for renewables, energy efficiency and innovation

[81] Although the evidence suggests that various key regulatory instruments, such as CO_2 intensity regulations for passenger cars and the Ecodesign Directive have not had any significant influence on the capital cost of related products thus far (Drummond, 2013a), it is reasonable to suggest that that may not be the case in future as 'low hanging fruit' becomes increasingly scarce.

investment for example, particularly in the incentive-based pathway with its expanded scope, may thus increase public support whilst creating a double dividend. Another element is the creation and promotion of 'co-benefits' from an instrument or instrument mix. For example, an instrument designed to reduce the CO_2-intensity of passenger cars, and which thus has the effect of encouraging deployment of electric vehicles and mode switching to active transport, induces not just a reduction of CO_2 emissions, but also local air pollutants and increased exercise, both with substantial (co-)benefits for human health (and associated reductions in healthcare costs, etc.) (Watts *et al*, 2015). The calculation, promotion and possible framing of instruments in terms of these co-benefits may stimulate additional acceptance, and even active (public and political) support. Indeed the protecting human health is an objective of environmental policy under the TFEU. The promotion of economic benefits of an instrument or instrument mix, from the impacts on GDP (discussed above), to the (positive) impact on future domestic energy bills, may have similar effects.

A final aspect of public acceptability concerns the presence of infrastructure required for the low-carbon transition in local communities (e.g. electricity transmission infrastructure). The presence and promotion of benefits of the low-carbon transition, and instruments and investments required to deliver it, as discussed above, may be a first step in encouraging acceptance of the presence of enabling infrastructure where required. Improved public participation, facilitated by the presence of a single focal point for such processes at the relevant governance levels, may be second. Additionally, stimulating community involvement and potentially ownership through local initiatives (such as the CoM) may spur interest in and acceptance of such infrastructure (Warren and McFayden, 2010).

Although many options presented would be most effective if introduced by legal requirement (through the introduction of new or amendment of existing Directives and Regulations, for example), and whilst some must be achieved through this approach (e.g. EU ETS reform), the political acceptability of instituting others as mandatory requirements for Member States is questionable. As such, the use of general and targeted recommendations (through the European Semester and perhaps processes under the Energy Union) and the issuance of guidance and best-practice sharing, to encourage the adoption of these options voluntarily in the first instance (where such mandatory approaches are questionable), and may be used to build support for a subsequent mandatory, legally binding approach.

Many options discussed contain, or are intended to, allow for flexibility in the instrument mix, and allow it to deal with uncertainties that may otherwise render it ineffective, cost-inefficient, or otherwise (politically) untenable. Key examples include the introduction of a Market Stability Reserve under the EU ETS (under both policy pathways), to reduce the risk of the carbon price returning to broadly ineffective levels, and the use of degression mechanisms in RES-E support mechanisms to prevent excessive deployment and associated costs[82]. Regular, pre-determined review and compliance periods, coupled with policy learning and information dissemination mechanisms (including through facilitating the emergence of 'frontrunners' that may act as 'policy labs') and regular reviews of the status of key technologies (through the SET-Plan, in particular), also contribute to 'future proofing' of the instrument mix. Similarly, the reduction and removal of concessions, such as 'super credits' under CO_2 intensity regulations for vehicles (under the technology-specific pathway) and the continued reduction and removal of free allocation to (an expanded range) of EU ETS sectors not considered at risk of carbon leakage (under both policy pathways), reduce and prevent entrenched roadblocks to appropriate revision and strengthening of the instrument mix (where required) in the future.

6 Summary and Conclusions

The existing climate policy mix is uneven, both in terms of coverage and stringency, within and between sectors and Member States. Despite this, it has delivered relatively substantial CO_2 abatement, with a positive overall impact on both GDP and employment, with no evidence of induced carbon leakage. Whilst economic instruments have been important, they are not exploiting their full potential as a result of design flaws, interactions with other instruments, and the presence of market distortions. Instead, regulatory instruments have thus far delivered a substantial proportion of policy-induced abatement. 'Non-Climate' instruments, and non-policy drivers, have also had a noticeable impact on GHG emissions in some sectors. Broadly speaking, information instruments have thus far had little influence on driving low-carbon investment and behaviour changes. Instruments of all descriptions, both at EU and Member State level, are often not designed to deal with or correct for unexpected developments or side effects, producing sub-optimal or even counterproductive outcomes, and reducing credibility. Additionally, Institutional and legal configuration, characteristics and procedures at both EU and Member State level has a substantial influence over whether an instrument or instrument mix is effective, or feasible to introduce in the first place.

In order to achieve the objective of a reduction in GHG emissions of 80% in the EU by 2050 (from 1990 levels), the rate of abatement across all sectors must increase substantially, driven by a comprehensive, effective, cost-efficient yet feasible instrument mix, and facilitated by appropriate governance and institutional structures and processes.

Such instruments and reforms must meet or overcome ten key challenges in both the short- and long-term (five systemic, five sectoral):

- Establish a Meaningful Carbon Price
- Complete the EU-Wide Electricity Market Reform and System Integration

[82] if costs of new installations fall faster than expected and growth in installations grows beyond reasonable expectations, a volume ceiling can trigger a reduction in the tariff. Where the constraint is financial, the ceiling could be based on support expenditure rather than volume (European Commission, 2013)

- Make Sounds Infrastructure Choices Despite Technological Uncertainty
- Provide Finance and Mobilise the Investments Necessary for a Low-Carbon Economy
- Encourage Low-Carbon Lifestyles
- ‘Fully’ Decarbonise the Power Sector
- Facilitate Low-Carbon Transport
- Tackle the Energy Consumption of the Housing Stock
- Stimulate Radical Low-Carbon Innovation in Industry
- Address non-CO_2 Greenhouse Gas Emissions, Particularly from Agriculture

Various options are presented to meet, or lay the foundations and trajectory towards meeting these challenges in the short-term (by 2030). In terms of ‘**framework’ conditions, and the reform and operation of public institutions**, key examples include maximising the potential benefits of EU-wide, supranational initiatives such as the Energy Union and Innovation Union concepts, along with leveraging the potential for subnational and regional governance initiatives (such as the Covenant of Mayors), to facilitate and encourage the emergence synergies, ‘frontrunners’ and ‘policy labs’ at all levels of governance. This is supported by the ‘mainstreaming’ of the low-carbon objective across all areas of policy making and investments made by public funds, or by public financial institutions. Indeed, dedicated funds and instruments for low-carbon development and innovation should be stepped up, at both the EU and Member State level. Ensuring clear an appropriate spatial planning regimes and administrative competences, perhaps unified in a single body at all relevant levels of jurisdiction, may overcome the need for several complex, unclear and disjointed processes, in turn reducing administrative barriers to the development of low-carbon infrastructure. The production of long-term plans by Member States helps highlight potential synergies between proposed low-carbon development pathways, helps identify and avoid conflicts before they occur, and helps recognise key areas of uncertainty for future focus. Increasing the application of monitoring and enforcement mechanisms, at both EU level and by Member States, would also likely prove beneficial.

In terms of broad policy instrumentation, two broad pathways are presented. The first is the **‘incentive-based’ policy pathway**, which focuses on pricing and other technology-neutral incentivising instruments to drive low-carbon investments and behaviour. A strengthened EU ETS, expanded to cover the residential heating sector, is the primary instrument and cornerstone of the instrument mix. This is supported by the introduction and harmonisation of a carbon price in the (road) transport sector, through CO_2-based vehicle registration and circulation taxes, and CO_2-based road pricing. Existing regulatory requirements and targets largely remain, but are generally not tightened, and many expire once time-limited targets are met. The second pathway is the **‘technology-specific’ policy pathway**, which focuses on regulatory targets and limits, and instruments that encourage particular technologies. Market-based instruments remain a strong feature, and may often be used to accelerate the development or increase the deployment of particular technologies. The role of pricing instruments is secondary in this pathway, and many existing ‘incentivising’ instruments (e.g. vehicle registration taxes), may be removed over time from a climate policy perspective.

However, regardless of the specific policy pathway taken, various **cross-cutting options** for the introduction of new and the reform of existing policy instruments are available. This includes the reform, where appropriate, of renewable support mechanisms and capacity mechanisms to ensure effectiveness, cost-efficiency and sustainability for as long as such mechanisms are likely to be required. Additionally, existing information instruments, which have had relatively little influence thus far, may be amended to ensure they present clear, reliable and appropriate information, whilst new information instruments may be introduced where they have thus far been underexploited. This includes the use of 'soft' transport measures, and potentially a 'food to fork' GHG accounting system for the integrated agri-food sector. Actions to reduce market distortions, such as those presented by company car taxation rules in many Member States, may also be taken.

Broadly, whichever policy pathway is taken and specific options implemented, **the design of individual instruments (both existing and new) and instrument mixes, and associated governance approaches, must be 'smarter'**, in order to deal with uncertainty, improve stability and increase confidence. Such an approach may be summarised into five key criteria:

a) **Effective targeting**. Targeting the scope of application where evidence suggests effectiveness is likely to high, rather than what economic efficiency may necessarily suggest (e.g. the use of CO_2-based registration and circulation taxes rather than a carbon price on fuel, under the 'incentive-based' policy pathway).
b) **Effective monitoring/compliance mechanisms**. Existing monitoring/compliance mechanisms for some instruments indicate technical compliance, but practical under-achievement, whilst others entail relatively significant administrative burdens that produce low levels of monitoring. Others render comparisons between Member States and over time extremely difficult, preventing accurate assessments of effectiveness.
c) **Allows for future revision if required.** In particular, avoidance of the installation of potential 'roadblocks' to revision, such as non-time limited/conditional exemptions or concessions.
d) **Able to deal with changing circumstances (both expected and unexpected)**. These may be self-induced, induced by other policy, or non-policy developments (e.g. technological development, economic growth, etc.). Examples include the Market Stability Reserve for the EU ETS, and the presence of degression mechanisms in renewable support mechanisms. This reduces need for revision, and provides long-term stability and confidence. With the above point, this may be called 'future proofing'.
e) **Inducement and promotion of positive co-benefits**. The earmarking of revenues from a pricing instrument, for example, may be used for particular purposes (e.g. EU ETS revenue used for deployment of renewables and energy efficiency, and to support industrial innovation), to increase acceptability of instruments and produce potential 'double dividends'. Intelligent 'framing' of an instrument to promote positive (e.g. health) co-benefits, may also improve public acceptability and political feasibility.

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