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

What constitutes an optimal climate policy mix?

Deliverable 1.1: Defining the concept of optimality, including political and legal framework conditions

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LIST OF ABBREVIATIONS

CO_2	Carbon Dioxide
EEA	European Environment Agency
ETS	Emissions Trading System
GDP	Gross Domestic Product
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development

CO_2	Carbon Dioxide
EEA	European Environment Agency
ETS	Emissions Trading System
GDP	Gross Domestic Product
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development

1 The Notion of Optimality

The CECILIA2050 project has set out to identify "optimal" mixes of climate policy instruments, with a view to achieving Europe's climate targets for 2050. In order to assess different policy instruments, CECILIA2050 will adopt a broad notion of optimality, which does not only analyse what looks best in theory, but also what is the most expedient way forward under real-life constraints

In order to identify the "optimal instrument mix" to tackle the challenge of climate change, we firstly need an understanding of optimality. In economics, "optimal" can generally be understood to imply the most favourable relation between the resources necessary to achieve an outcome, and the outcome itself. If the outcome is not determined exogenously, an optimality assessment would determine both the optimal outcome and the optimal resource input, as e.g. in a cost-benefit analysis. Thus, it assesses not only the least-cost way of achieving a certain target; the optimality assessment also investigates whether the objective is worth achieving in the first place, or whether resources are better allocated to other, competing uses.

In the case of European climate policies[1], however, the desired outcome is given, namely in the form of the EU's long run climate targets: the short-term target of a 20%-reduction of Greenhouse Gas Emissions by 2020, as well as the aspirational target as expressed, inter alia, in the EU's "Roadmap for moving to a low-carbon economy in 2050", which suggests a reduction of CO_2 emissions of 80% by mid-century, as well as milestones of a 40%-reduction by 2030 and a 60%-reduction by 2040.

In the CECILIA2050 project, the optimality therefore does not include an assessment of whether the costs of reaching the EU's climate targets are justified by the benefits of avoided climate change.[2] Instead, the project takes the EU climate targets as a given starting point. Optimality thus becomes a question of cost-effectiveness: how can we ensure that the EU's long-run climate targets are achieved at the lowest cost to society?

Answering this question is far more complex than simply taking an abatement-cost-curve, identifying the least-cost abatement options and choosing suitable policy instruments to

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[1] Climate policies, as used in this report, refer only to the mitigation of climate change, i.e. reduction of greenhouse gas emissions. On the link to the other major domain of climate policy, adaptation to the impacts of climate change, see the discussion in chapter 6.

[2] In other words, CECILIA2050 does not set out to assess whether the proposed policies lead to efficient outcomes in a macroeconomic sense, where the efficient allocation of resources would maximise the economy-wide welfare. Such an assessment would entail a comparison whether more welfare can be generated if resources are allocated to objectives other than climate protection, e.g. to education, health care or consumption. Neither does CECILIA2050 assess whether the EU climate policy strikes an optimal balance between avoiding climate change (=emission reduction, or mitigation policies), and between adapting to the unavoidable impacts of climate change (=adaptation, or even geoengineering).

realise the abatement options. Finding the optimal, least-cost path to the EU's long-run climate targets necessarily involves a great amount of uncertainty, and requires a dynamic perspective: many of the solutions (technological, organizational, social or otherwise) that will be needed to de-carbonise Europe's economy do not yet exist, but still need to be developed. At the same time, the capacity to absorb the necessary changes is not unlimited: social hardships and distributional impacts, public acceptance and legal-procedural requirements all impose constraints on this transformation process that need to be observed.

Identifying one "optimal" course for the next 40 years seems like an over-ambitious (and quite possibly pointless) endeavour. Technologies and knowledge evolve, political and social conditions change, and therefore the policy instrumentation will also need to remain adaptable. At the same time, economic actors need stable and reliable framework conditions for their decisions, some of which may have an equally long time horizon. Therefore the direction of the transformation process needs to be set out clearly.

2 The Need for a Broad Concept of Optimality

Much of the existing policy analysis, especially when conducted from an economic angle, suffers from an unhealthy focus on the criterion of static efficiency. Such analyses are quick to recommend pricing tools as the cost-minimising solutions, ideally implemented internationally and encompassing all sectors. However, as a guiding principle for policy evaluation, this point of view is simplistic and naïve because it neglects many real-world features, which limit the effectiveness of pricing tools:

- There are other market failures than climate change. For example, the landlord-tenant dilemma prevents many financially profitable energy-efficiency investments from being implemented, even for a high CO_2 price (IEA, 2007). Some of these market failures can be tackled by specific additional policies, but not all of them.
- Technical progress is induced by climate policies but its rate differs across technologies, which justifies a higher (implicit) CO_2 price for some technologies, as well as specific targeted support other than CO_2 pricing). For instance, wind energy was not cost-efficient in a static sense when the first wind support policies were implemented but this early implementation contributed to reduce wind energy cost through induced technical change (Isoard and Soria, 2001).
- Administrative feasibility (monitoring and enforcement) differs widely between, for example, CO_2 emissions by large combustion installations and N_2O emissions from agriculture. Policy instruments that may be effective and efficient for large, centralised emitters may be entirely inadequate and inefficient for small emitters, simply because the transaction cost of compliance and monitoring far exceed any efficiency gain associated with the instrument.

- Political and legal constraints prevent the implementation of some policies; for example, taxation of GHG emissions in non-ETS sectors is made difficult at the EU level by the unanimity decisions rule and in at least one Member State (France) by the fact that the highest court has rejected a CO_2 tax proposal on the ground that it did not cover emission sources covered by the ETS.
- Distributional impacts and equity issues may lead to reject the policy option which has the lower aggregate cost if this cost burden is too unevenly spread, and if it is not possible to correct for this through flanking policies for economic or other reasons.
- What ultimately matters to prevent dangerous climate change is not European emissions but global emissions, and European climate policies can both increase foreign emissions (carbon leakage) and reduce them (spillovers).

This selection, which could be continued, underlines that more conventional research approaches, focusing exclusively on narrow definitions of economic efficiency, risk overlooking crucial factors when assessing policy instruments and their combinations. Some of the factors that may turn out to be decisive for the actual performance of instruments – such as the quality of implementation – are often buried in the model assumptions, but not explicitly recognised. This may lead to simplified conclusions and, in the worst case, flawed, biased or simply unpractical recommendations. Hence CECILIA2050 will focus on a broad notion of optimality which takes into account other market failures and imperfections other than climate change, such as induced technical change and technological spillovers, administrative and legal constraints, transaction costs, distributional impacts and associated problems of public acceptance, carbon leakage and spillovers through international trade.

3 Criteria for Assessing the Optimality of Climate Policies

The notion of optimality that underlies the CECILIA2050 project builds on comparable surveys and evaluations of economic instruments for climate policy, and for environmental policy more broadly. Such surveys have been produced inter alia the OECD, the IEA and the EEA (Hood 2011, Duval 2008 and Smith 2008), but have also been published widely in academic literature (e.g., Sorrell 2003, Konidari and Mavrakis 2007).

There is no universally agreed set of specific criteria for what constitutes an optimal policy mix – neither in the academic literature that has assessed the performance of climate policies, nor in the policy evaluation literature more broadly, nor in the handbooks and guidelines for applied policy evaluations that have been put forward by organisations such as the European Commission, the IPCC or the OECD. Yet, when looking at the criteria that different evaluations of climate policies have used, or that different guidelines put forward to assess the performance of policies, there is broad overlap among them. The different criteria can be sorted into three categories:

- Measures of the **effectiveness** of policy interventions: are the policies achieving their objective(s)?

- Measures of the **cost-effectiveness** (or efficiency) of policy interventions: at what cost have the effects been achieved, what is the relation between the inputs and the outputs or impacts of a policy?
- Measures of the **practical feasibility** – including measures of the ease of implementation, the real-life constraints and the side-effects that can jeopardise a successful implementation of policies.

3.1 Effectiveness – is a policy achieving its objectives?

The criterion of policy effectiveness – is the policy achieving its objective(s) – is the most obvious evaluation criteria, and is listed as the first criterion by any evaluation framework or applied policy evaluation. While the criterion as such is fairly intuitive, a number of caveats and considerations apply:

- Effectiveness measures the results of a policy intervention. These results can be described as **policy outputs** (e.g. laws and regulations passed), **policy outcomes** (e.g. share of renewable energy or number of electric vehicles), or **policy impacts** (e.g. dangerous anthropogenic climate change avoided) (EEA 2001). Clearly, the longer the causal chain from a policy intervention to the result, the larger the number of confounding factors and other influences, and the more difficult it becomes to attribute a particular observed change to a specific policy intervention (Hatch 2005).
- Which of the different results is applicable (outputs, outcomes or impacts) will also depend on the **nature of the policy objectives**, i.e. whether the objectives have been defined in terms of outputs (unlikely), outcomes (most likely), or impacts (less likely). While the yardstick for climate policies is ultimately the concentration of greenhouse gases in the atmosphere and the associated global warming, such impact measures are impractical to capture the effects of a policy intervention. Instead, the objective of climate policy interventions is typically defined either in terms of the avoided greenhouse gas emissions (compared to a base year or baseline), or in terms of the policy-induced outcome that is considered necessary to bring about emission reductions, such as the share of energy that comes from renewable sources, or improvements in energy efficiency.[3]
- A systematic evaluation is often confounded by the fact that the objectives of a policy intervention are not always clearly specified, let alone quantified. Often, a policy intervention will serve different objectives, but not necessarily identify a hierarchy of the different objectives. In the case of climate policies, there is of course a suite of climate policy instruments with the (direct or indirect) objective of reducing greenhouse gas

[3] A case in point are the EU's "20-20-20 targets", by 2020, to reduce greenhouse gas emissions 20% below 1990 levels, to raise the share of energy produced from renewable sources to 20%, and to improve the EU's energy efficiency by 20%, as adopted by the EU heads of state in March 2007.

emissions.[4] But contributions to climate mitigation may also come from interventions motivated by e.g. energy, transport or air quality objectives, with greenhouse gas emission reductions at best as a secondary objective.

The last point leads over to the question of dealing with side-effects: climate mitigation policies can give rise to a number of side-effects, both beneficial and undesirable, both intended and unintended, possibly related to other environmental domains or also to other policy objectives. As noted, policy makers may not distinguish between the primary and the secondary objectives of a proposed policy, which would allow for a distinction between effects and side-effects, but simply list a number of purposes that the regulation is intended to serve.[5] Side-effects of climate policies that have featured prominently in the public debate may include:

- Beneficial side-effects: job creation, innovation and technological leadership, economic restructuring and regional development, air quality improvements from reduced fossil fuel combustion and associated health benefits, reduced resource consumption (and associated environmental benefits, e.g. water, land, etc.), reduced dependence on fossil fuel imports, etc.
- Negative side-effects: Higher energy prices and associated knock-on effects (equity impacts, reduced competitiveness of energy-intensive industries, wider economic impacts including job losses), impacts on local environment and biodiversity (E.g. biofuels – water consumption and soil degradation, wind – impacts on landscape and scenery, water – impact on fish migration, etc.), devaluation of existing energy infrastructure (stranded assets), re-direction of investments from alternative, potentially more productive uses, etc.

As becomes clear, the different side-effects operate in the same categories (of employment effects, wider environmental effects beyond climate mitigation, and economic effects). For most policy instruments, and certainly for climate policy as a whole, whether the positive effects will outweigh the negative or vice versa, will depend on the analytical framework applied, and a number of key assumptions. Whether, for instance, the “green jobs” created in sectors like the design, manufacture, installation and maintenance of renewable energy technologies outweigh the possible employment impact of higher electricity prices due to renewable support, remains contested.

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[4] Emissions trading is a special case in this regards, as the emissions ceiling – and thus the emission reduction compared to the baseline – is an integral part of the policy instrument. In this case, the environmental effectiveness is sometimes referred to as the “environmental integrity” of the scheme, i.e. the capability of the instrument to ensure that the regulated emissions remain below the emission ceiling.

[5] Indeed, the logic of “win-win-solutions” is that different objectives can be achieved at the same time, and that the distinction between primary and secondary objectives becomes obsolete. The same point can be made about the very concept of sustainable development, which may be interpreted to require that the economic, social and environmental dimensions of sustainable development are achieved jointly, and that policies should ideally promote all three dimensions at the same time.

There are different options how side-effects can be accounted for in the set of evaluation criteria discussed here.

- They can be part of the effectiveness criterion – using a wide notion of a policy's "effect" to include all effects, intended and unintended;
- They can be part of the cost-effectiveness (efficiency) – following a wide notion of the costs imposed by a policy, understood as all resources employed to achieve the desired effect;
- They can be seen as a (key) determinant of the political feasibility – seeing that the side-effects are very relevant to key stakeholder groups like labour unions, business associations, and environmental groups, and of course to policy makers.

This report argues that they should be part of the (social) cost – understood more broadly as the welfare impact of a policy, which can be both positive and negative. As is explained in greater detail below, the assessment of the costs of a policy should reflect the scope of the instrument. For an assessment of the overall costs of climate policies, all costs to society should be considered, including non-market costs (e.g. effects on the environment), second-order effects on the wider economy, and employment effects. As argued above, these wider effects may turn out positive or negative on balance, irrespective of the fact that they are discussed under the heading of costs. Further, side-effects will also feature prominently as determinants of the political acceptability – in particular, equity and competitiveness impacts will have a significant impact on the public support for and political traction of proposed climate policies. Yet, while important, they are only of indirect relevance for political feasibility: the existence of side-effects does not, in and of itself, limit political feasibility – depending on whether, for instance, flanking measures are part of the policy mix that help to offset undesirable side effects.

3.2 Cost-effectiveness – are the effects achieved at least cost?

As with effectiveness, the criterion of cost-effectiveness is included in almost any evaluation framework or applied policy evaluation. By relating inputs (costs) to the results (effects) of a policy intervention, it provides a measure of the efficiency of the policy intervention: is the objective of the policy intervention achieved at the least cost to society?[6]

The criterion of cost-effectiveness can be further described with two sub-criteria, namely static and dynamic efficiency.

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[6] In the literature, the terms "cost-effectiveness" and "efficiency" are used synonymously. In this document, we refrained from using "efficiency" as a stand-alone term, since the term efficiency is also used in macroeconomics to describe a welfare-maximising allocation of resources. In this understanding, an "efficient" climate policy would be one that maximises welfare, i.e. sets the level of mitigation effort to maximise the difference between economy-wide costs and benefits (avoided climate change impacts). As argued above, such an analysis, which would aim to derive "optimal" climate targets from a welfare maximisation perspective, is not foreseen in this project, which instead takes the existing EU climate policy targets as a given starting point.

Static efficiency implies that a policy achieves its objectives at least cost, *given the currently available abatement options*, by inducing emission reductions across the economy, wherever they are cheapest. This requires that all emission sources are covered by the set of climate policy instruments, and that all emitters face an equivalent incentive to reduce emissions – be it through a carbon price or some other incentive mechanism. In theory, then, the marginal abatement costs of reducing emissions should be equal for all emitters, reductions should take place where they are cheapest to obtain, and the overall cost of achieving a given reduction target should be minimal (Hood 2011, Duval 2008, Sorrell 2003).

In contrast, the concept of **dynamic efficiency** refers to minimising the cost of achieving climate targets *over a given time period*, by giving emitters a continuous and ongoing incentive to search for cheaper abatement options (Duval 2008, p. 17). For instance, a regulation that prescribes the use of a certain technology does not provide any dynamic incentive – once the emitter complies with the regulation, there is no incentive to go beyond the standard prescribed in the regulation. By contrast, a price-based instrument provides an ongoing incentive to reduce emissions, since every additional ton of emission reductions corresponds to cost savings.

The concept of dynamic efficiency is linked to the capacity of a policy instrument to induce **innovation and diffusion** of low-carbon technologies, in order to lower abatement costs in the future. The main difference to the concept of static efficiency is therefore that the abatement options and their costs are not taken as given, but rather treated as a factor that can (and has to) be influenced by policies. From a dynamic perspective, it may thus be advisable to fund of technologies that would appear as inefficient (unnecessarily costly) in a static view, but that promise to deliver low-cost abatement potential in the future, or help to avoid situations of technological lock-in. As a forward-looking criteria, dynamic efficiency inevitably involves an element of uncertainty: as the cost and the viability of new, low-carbon technologies cannot be predicted with certainty, it will also be difficult to specify exactly the efficient level of investment into the innovation and diffusion of low-carbon technologies.

An important distinction concerns the types of costs that should be considered in the analysis of cost-effectiveness. In principle, the type of costs should reflect the scope of the instrument. To assess an instrument with a small impact on a limited part of the economy, a partial analysis may suffice. However, climate policy as a whole is expected to transform a significant part of the economy. Instruments of climate policy already affect the prices of key intermediate inputs like electricity or transport fuels that have an impact on the wider economy, and thus create the potential for knock-on effects on employment, GDP and welfare (Hood 2011). At the same time, the revenue raised from economic instruments, if used wisely, may offset some of the undesirable knock-on effects, e.g. stimulating employment by reducing labour taxes.

A basic, but nonetheless important distinction is that between costs and investments: whereas investment needs (and associated capital costs) induced by climate policies will be high at the outset, these will often be balanced by cost savings at a later stage, such as reduced expenditure for fossil fuels (Hood 2011). To assess the cost-effectiveness of policies, it is necessary to consider the net costs, accumulated and discounted over time. In a macroeconomic framework, this also includes the opportunity costs of investments, i.e. the foregone returns that investments would have delivered in alternative, potentially more productive uses.

Where relevant, an assessment of the welfare effects may also include non-market effects, e.g. in the case of trade-offs between climate protection and other environmental objectives. A case in point would be the impacts of biofuel production on soils, water, and agro-biodiversity – to the extent that they can be captured in monetary terms, such impacts would also count to the total cost of biofuels.

3.3 Feasibility – what is the risk of policy failure?

The third category, addressing the feasibility and aspects of practical implementation, is the most heterogeneous of the three. While most evaluation guidelines and empirical assessments apply further criteria beyond effectiveness and cost-effectiveness / efficiency, these criteria cover a range of different aspects. A common feature of the different measures is that they address the risks that a planned policy (i) might not be implemented as designed (at the level of policy *outputs*), or (ii) that the policy might not deliver the expected results once it has been implemented (at the level of policy *outcomes*), including unintended side-effects.

The different criteria thus address the difference between policies as they are conceived on the drawing board, and their actual performance in real life, and are therefore subsumed under the heading of feasibility. While it does not seem possible to develop a continuous metric for feasibility, it is clear that feasibility is a scalar concept. Thus, the criterion does not sort policy proposal into those that are feasible and those that are infeasible, but rather provides information on the degree of feasibility (or the risk of failure).

The range of different feasibility aspects is listed in Table 1 below. They can broadly be categorised as follows:

- Criteria on the **administrative implementation**, including the ease of administration, transaction costs (both on compliance entities and the public bureaucracy), transparency of implementation, stringency of the compliance regime, etc.;
- **Unintended side-effects** that may either lead to a re-assessment of the policy's desirability, or (if the policy is implemented nonetheless) that may lead to opposition by key stakeholders or by the public at large, and therefore to imperfect implementation. The two main types of such side-effects are distributional / equity impacts, and impacts on the competitiveness of domestic industries;

- Related to the former are the aspects **political acceptability** – whether a policy proposal is likely to gain political support, and whether it is coherent with overarching policy objectives (which would include solidarity, equity and competitiveness);
- A specific interpretation of the coherence with overarching policies leads to the **legal and institutional feasibility** – how well does a policy proposal blend in with existing laws and regulations, is it compatible with constitutional doctrines? In the case of European policies, it could also be asked whether a policy contributes to better harmonisation and cooperation in Europe, including a single market;
- The **flexibility** / adaptability of policy instruments in response to new information, as well as the capacity of an instrument to deal with **risks and uncertainties**, which can be related both to the availability and cost of abatement options, and to the climate science (Duval 2008).

The latter could be further specified to the robustness of an instrument when faced with **strategic behaviour** – e.g. whether an instrument's performance is affected by imperfect or asymmetrical information, whether it is likely to attract rent-seeking or other undue influences from vested interests (regulatory capture), or whether it is vulnerable to fraud. Obviously, most of these aspects are not only inherent to the choice and design of a policy instrument, but are also influenced by its administrative implementation: for instance, the transparency of implementation and the stringency of the compliance regime will affect the influence of vested interests and the risk of fraudulent behaviour.

As argued above, the impact of a policy on innovation and technology development would be captured in the dynamic efficiency property. Yet it has also been discussed to consider technological feasibility as a criterion in its own right. Both the static and dynamic efficiency criteria are based on the logic of abatement cost curves, which suggest a continuum of abatement options. In the dynamic view, R&D will generate further abatement options and drive down the cost of existing ones, with abatement cost reduction as a function of R&D spending. Dynamic efficiency thus becomes an optimisation problem: an efficient level of technology development is achieved when the sum of R&D spending and actual abatement is minimised. Still, given the complexities of managing innovation processes, and the inevitability of failures and dead-ends in the process, it is also possible to conceive of hard limits on the speed of innovation and the roll-out of new technologies. In this reading, the development of new low-carbon technologies may hit a limit where the process simply cannot be accelerated.

To conclude, the criterion of feasibility is clearly important as a reality check for the design of "optimal" climate policies. The methodologically rigorous inclusion of feasibility among the criteria for policy assessment, and the testing of different approaches to analyse feasibility represents one of the main innovations of the CECILIA2050 compared to the state-of-the-art of climate policy analysis. Indeed, the failure of some existing policy analyses to adequately reflect the feasibility of proposed policies has weakened their recommendations. Yet the introduction of feasibility is not without problems: the challenge is not to let the concept become too subjective, and thereby ultimately arbitrary, which would render it irrelevant as a guiding criterion for sound climate policies.[7] Another risk is that the introduction of political feasibility may also invite gaming and strategic behaviour on the side of policy makers and stakeholders: knowing that most benefits of climate policy are shared internationally, but most costs are borne nationally, it may seem attractive to remain in a laggard position, quoting political feasibility restrictions as the reason for the lack of action. The best way of addressing these risks is to base the feasibility criterion on solid analysis; and this is exactly what several tasks within the CECILIA2050 project have set out to do.

Table 1: Evaluation criteria for climate policies applied in the literature

Source	Effectiveness	Cost-effectiveness	Feasibility / other
IPCC (2007)	Environmental effectiveness	Cost-effectiveness	Distributional considerations, institutional feasibility
Duval (2008) (OECD)	Effectiveness	Static and dynamic efficiency	Responsiveness to risks and uncertainties
European Commission (2009)	Effectiveness	Efficiency (cost-effectiveness)	Coherence (with overarching EU policy objectives)
Sorrell (2003)	Environmental effectiveness	Economic efficiency (static and dynamic)	Administrative simplicity, equity, political acceptability
Konidari & Mavrakis (2007)	GHG reductions, other environmental effects	Efficiency (static and dynamic)	Competitiveness, equity, flexibility, non-compliance stringency, administrative and financial feasibility
Hatch (2005)	Environmental effectiveness	Cost-effectiveness	Policy efficiency (acceptability and viability), administrative efficacy (implementation and compliance), innovation
GAO (2008)	Environmental	Cost-effectiveness	Political feasibility,

[7] This is exacerbated by the fact that – in particular – political feasibility is not an absolute, given constraint. Rather, it is a legitimate objective of public policy to improve the conditions for political feasibility – by changing the public perception, through awareness-raising campaigns and education, and by engaging in the public discourse. Also, the assessment of what is or is not feasible may change radically and rapidly due to external events – as witnessed e.g. in Germany in the aftermath of the Fukushima nuclear accident.

	effectiveness		flexibility, predictability, effect on international efforts, transparency, administrative ease, implementation cost, rent seeking, emissions leakage, distribution of cost etc.

3.4 Interrelations between the different criteria

In each of the sets of criteria applied or advocated in the literature, interrelations exist between criteria. In particular, the feasibility criterion (in its different interpretations) has implications for the performance of policy instruments in terms of their effectiveness and their efficiency, or cost-effectiveness. There are different options how feasibility considerations can be integrated in the assessment of policy options: Feasibility can either be treated as additional, separate information (capturing the risk that a policy may fail to be adopted, or if adopted, may fail to be fully implemented). Or it can be conceived as a real-life check on the criteria of effectiveness and cost-effectiveness – either by discounting the effects of policies, or as a mark-up to the cost of policies, as the real-life performance on both criteria will differ from the theoretically expected performance.

- Following the first logic, feasibility is treated as a separate, additional criterion. Feasibility then serves as an indication where the first-best option, although it may perform well on paper, is unlikely to be adopted or to be implemented in practice. Hence, the option that is second-best (third-best, …) in terms of effectiveness or cost-effectiveness may become the best available course of action, if it is perceived as more feasible. At the extreme case, a policy that is considered as completely infeasible is simply not an option.
- Following the second logic, a policy with questionable feasibility is one that is going to meet resistance, and is therefore less likely to perform as anticipated, and to achieve its intended effects. In other words, the policy's actual effectiveness will be lower than projected in theory. Alternatively, the feasibility constraint will result in costs that are higher than anticipated (e.g. where reduction efforts are redistributed among actors based on political expediency, or where a higher administrative effort is required to ensure compliance), and hence cost-effectiveness will be worse than projected. In this reading, feasibility adds a discount on the projected effectiveness of policies (or a mark-up to its cost. A similar idea is captured in the concept of *efficacy*: in medicine, efficacy describes the beneficial change that an intervention (e.g. a drug, treatment or a surgical procedure) can achieve *in an ideal situation, i.e. under laboratory conditions or in a tightly controlled clinical trial*, whereas effectiveness measures how well a treatment works in a real-life situation (Thaul 2012). In this understanding, the *efficacy* of a climate policy would describe the performance of climate policies in a world without feasibility

constraints, whereas the effectiveness would measure their actual performance acknowledging constraints on feasibility.

A criticism of the second option is that the *efficacy* of a policy instrument remains a purely theoretical exercise: first, it begs the question how “laboratory conditions” can be emanated for a climate policy instrument, and second, it would suggest to just integrate the feasibility aspect into the effectiveness and cost-effectiveness assessment– thereby masking some of the trade-offs involved. As such, the first option would seem more suited to make the trade-offs between theoretic performance and implementation risks explicit and transparent.

To give an example of what the feasibility vs. effectiveness / efficiency trade-off could look like, the inclusion of a feasibility criterion would also entail that some policies might be deemed politically acceptable in some EU Member States with a stronger disposition for ambitious climate policies, whereas similar policies would be infeasible in others. Acknowledging these constraints suggests that some countries undertake more efforts than others, and do so at a higher cost. As a consequence, the set of European climate policies as a whole has to become less cost-effective in order to accommodate feasibility constraints.[8]

As a second example, derogations and exemptions for particularly vulnerable (or particularly vocal) groups might be seen as inevitable to secure political support from key stakeholders. Yet, these exemptions also render the policies less effective less efficient and more complex to administer; they may impose undesired distributional impacts on other, less vocal groups, and thereby ultimately jeopardise the public acceptability of the policy instrument.

Last not least, and to complicate things further, the interaction between feasibility on the one hand and the effectiveness and cost-effectiveness of policies on the other hand also works in the opposite direction: the political acceptability of policy proposals is also influenced by their expected or perceived effectiveness and cost-effectiveness. Policies that are seen as ineffective or unnecessarily burdensome are less likely to find public support, and to gain political traction.

[8] This interpretation presents (political) feasibility as a constraint that will reduce the cost-effectiveness of climate policies, but has to be acknowledged as an inevitable fact of life. There are also more favourable interpretations: first, national differences in the level of ambition can be ascribed to the political preferences in the different countries. If voters in one country have a higher preference for climate protection than another, and are prepared to pay for their preference, differences in the level of ambition would be a logical result – to the detriment of overall efficiency, but in line with national preferences. Second, differences in the level of ambition can also be justified on the grounds of solidarity (richer countries are able to do more, and hence should do more), or historical responsibility. This understanding echoes a fundamental principle of the international climate regime (common but differentiated responsibilities), but may conflict with a distribution of effort that would minimise costs.

4 Towards a Definition of “Optimality”

In order to evaluate and compare different policy options, and to identify a policy mix that is optimal under given constraints, the CECILIA2050 project will use a set of criteria that covers three dimensions: (i) effectiveness – are the policies sufficient to bring about the emission reductions required by policy; (ii) cost-effectiveness – are emissions reduced at least cost, now and over time, and (iii) feasibility – what is the risk that the policy fails to be adopted and subsequently implemented as planned (outputs), and the risk that the instrument, when implemented, fails to deliver because of political, legal or administrative constraints (outcomes). These three criteria are explained in greater detail below.

I. **Environmental effectiveness.** The most important yardstick is whether the proposed policies can be expected to bring about the necessary emission reductions (in the order of 80% below 1990 levels by mid-century). Environmental effectiveness does not only imply that the emission reduction potentials that are known and available today are realised. It also means that the European economy is placed onto a development pathway that is compatible with the EU’s long run climate goals, e.g. through incentivising the necessary R&D and investment for a transformation of the economy. Effectiveness will be assessed in terms of EU-wide impacts (based on scenarios of how climate policies in the rest of the world will evolve), as well as analysing the global effects of European climate policies;

II. **Cost-effectiveness** (efficiency). At what cost are the necessary emission reductions achieved – and does the instrument mix guarantee that they are met at least cost. This criterion is further spelled out in two sub-criteria:

    a. **Static efficiency.** This is achieved when the marginal costs of reducing emissions by one additional unit are equal for all emission sources, across the economy. This requires that all emitters are covered by the set of policy instruments, and that all emitters face an equivalent incentive to reduce emissions – be it through a carbon price or some other (dis-)incentive.[9] In theory, when the marginal abatement costs is equal for all emitters, the overall cost of achieving a given reduction target is minimised (with given technologies). By contrast, situations with incomplete coverage or strongly diverging incentives for carbon abatement would suggest that some actors’ reduction efforts are significantly higher (and more costly) than that of others, and that overall (static) efficiency could be enhanced from a reallocation of abatement efforts.

[9] By extension, it is often argued that static efficiency is achieved when there is a uniform carbon price across the economy. Note, however, that the condition for static efficiency hinges upon the equalisation of marginal abatement costs across emitters: if the response of certain groups of emitters is affected by barriers and constraints (such as transaction costs), so that their response to a given carbon price is consistently different from that of another group of emitters, deviations from a uniform carbon price could be compatible with static efficiency.

b. **Dynamic efficiency.** This entails an efficient level of innovation and diffusion of low-carbon technologies in order to lower abatement costs in the future. In this way, dynamic efficiency is a way of minimising the total cost of achieving climate targets over a given time period. This may include funding of technologies that would appear as inefficient (unnecessarily costly) in a static perspective, but that are justified through their dynamic effects, as a way of avoiding situations of technological lock-in.[10]

III. **Feasibility.** At an abstract level, this describes the risk that the policy fails to be adopted and subsequently implemented as planned (outputs), and the risk that the instrument, when implemented, fails to deliver as expected (outcomes). This can be assessed in several dimensions:

a. **Political feasibility:** acceptance or resistance of policies by the public at large (in their function as voters or as consumers), and support for climate policy by policy makers and stakeholders, who are willing to promote or to defend such initiatives. The political feasibility is influenced by a range of (intended and unintended) side-effects, including distributional / equity impacts, impacts on the competitiveness of domestic industries, and effects on job creation or local air quality. Political feasibility mainly imposes a constraint for the adoption of policy instruments (i.e. arriving at policy outputs), but may also hamper the performance once policies have been implemented (generating policy outcomes).

b. **Legal feasibility:** this concerns the compatibility and coherence of climate policy instruments with existing EU legislation (primary and secondary), as well as national legislation. New policies do not operate in a legal and institutional vacuum, but need to function in tune with existing norms, regulations and institutions. These pre-existing norms will affect both the choice of policy instruments, as well as their performance once implemented. In the extreme case, policy options may be ruled out entirely if they are deemed to conflict with existing norms.

c. **Administrative feasibility:** administrative burden for compliance and enforcement (including the monitoring, reporting and if necessary verification of emissions), covering both the transaction cost (bureaucratic burden) for regulated entities, and the administrative effort required by government agencies to effectively implement an instrument and ensure compliance. Again, the set of existing environmental regulations in a country would shape the administrative infrastructure on which new policy instruments can build. Administrative feasibility is less of a constraint in the adoption and planning phase, but rather in the actual implementation (moving from policy outputs to outcomes).

[10] The discussion of dynamic efficiency is related to other temporal properties of a policy instrument, such as the flexibility to adapt an instrument on the basis of new information, and the instrument's ability to generate a credible long-term signal for consumers and investors.

These criteria describe general concepts that need to be considered when assessing a set of policy instruments. Part of the intellectual challenge for CECILIA2050 is to develop these general concepts into more concrete measures, which can be compared across different instruments, or even aggregated.

5 Measuring Optimality

5.1 Measuring the Different Optimality Criteria

For some of the optimality criteria described above, there are established metrics and indicators – whereas others do not lend themselves to quantitative measurement, but rather need to be described in qualitative terms.

- For **effectiveness**, the unit of measurement depends on how the objective of the policy intervention has been specified. For climate mitigation policies, reducing greenhouse gas emissions is either a direct or indirect objective of any policy instrument;[11] the effectiveness is then measured as reduced tons of CO_2 emissions (or CO_2-equivalent), compared to the baseline, for a given time period or target year.
- For overall **cost-effectiveness (efficiency)**, a typical measure of the cost-effectiveness is the (average) abatement cost per ton of avoided CO_2-emissons; however this measure is most relevant at the level of individual projects, and less useful at the level of policies. For the assessment of static efficiency, a relevant criterion is the spread of actual abatement costs across sectors and across policy instruments.
- **Feasibility** only partially lends itself to quantification – indicators can help to understand the feasibility constraints, but not measure feasibility as such.[12] Nonetheless, it should be clear that, irrespective of the question of measurement, feasibility should definitely be understood as a scalar concept, i.e. with different degrees of (in)feasibility, rather than a binary yes/no-criterion.

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[11] Even within climate policies in a narrow sense, there are numerous other objectives – and hence effectiveness indicators. These may include, for instance, the share of renewable energies in the energy mix, the carbon intensity of the energy mix, energy consumption (absolute, per capita or per unit of GDP), energy intensity per unit of GDP, technology-specific indicators for the uptake of technologies like CHP, CCS etc..

[12] For instance, regarding administrative feasibility, the Standard Cost Model (SCM) is now used widely across EU Member States and the EU itself as a measure of the bureaucratic burden imposed by regulations (Wegrich 2009). While the bureaucracy costs as measured through the SCM reflects only part of the administrative feasibility, namely the burden on regulated entities, and while the measure itself is not without its problems, it can serve as input to the assessment of administrative feasibility.

5.2 Aggregating Different Criteria to a Joint Concept of Optimality?

Classical economics is largely about optimisation, often seen as the search for a unique, optimal result that maximises a given objective function or minimises inputs. In this logic, it would be tempting to develop an objective function for “optimal climate policy”, which quantifies the trade-offs between the criteria of effectiveness, cost-effectiveness and the different aspects of feasibility, and which incorporates the constraints posed by different criteria. Identifying the optimal policy mix for European climate policy would then be a matter of maximising the objective function, subject to given constraints; the result would be a suite of policies that (based on the assumptions made) promises to achieve Europe’s climate targets at minimal cost.

The practice, however, shows that some of the criteria do not lend themselves to quantification (and are therefore often simply excluded in purely quantitative assessments), nor do the trade-offs between the different criteria (van den Bergh 2004). Aspects such as political feasibility can be analysed using quantitative techniques, but are not easily captured in a single indicator or set of indicators. Also, trading off the different aspects of climate policies is at the heart of the political process, and will inevitably involves normative judgements (e.g. when trading off a lower overall cost to society against impacts on particularly vulnerable groups, against the risk of failing to achieve a given environmental target). That is, the trade-off will certainly benefit from a solid empirical foundation, and can be better understood through the use of participatory methods, but cannot be replaced through an abstract optimisation. For this reason, most applied analyses in search of an “optimal” climate policies typically resort to approaches that more or less closely resemble a multi-criteria analysis, including some participatory elements, which follow a structured and transparent process in order to weigh and trade off the different criteria (Guglyuvatyy 2008, Konidari and Mavrakis 2007, van den Bergh 2004).

An alternative approach, which falls short of quantifying all criteria and their trade-offs, is to establish a hierarchy among them. As such, though, there is no abstract and absolute hierarchy among the criteria described above, as this too depends on the values and political priorities involved. Thus, from an environmental integrity perspective, the effectiveness of a (set of) policy instrument(s) might be considered as the most important criterion; any set of policies that fails to achieve the given environmental targets would be seen as inferior, irrespective of its other merits. By contrast, a pragmatic take would be that feasibility is paramount, and that policy proposals that stand a small chance of actually being adopted and implemented are merely theoretical options, and can be safely ignored.

The CECILIA2050 project will follow the second logic, in the suite of the multi-criteria-type assessments. Where overall assessments of optimality are required, and therefore an aggregation of the different criteria is needed, this should be done in a transparent weighting process, where possible and where appropriate involving stakeholder input.

6 Optimality - at which Level?

Whereas the previous sections presented the criteria through which the concept of optimality can be illustrated, the following session will discuss the scope of the analysis. The issue of optimality can be discussed at different levels of aggregation:

a. At the level of individual policy instruments: is the individual climate policy instrument well-designed and performing as planned, or how could the instrument be enhanced through design changes?
b. At the level of the instrument sets or mixes that shape climate (mitigation) policy: are the different climate policy instruments well-integrated, coherent and consistent, and do they cover all major sectors and emitters? Are the different instruments designed to be mutually supportive, or are they in conflict? This, in turn, can be discussed either for specific sub-sectors of climate policy (such as renewable support or energy efficiency), or for climate mitigation policy as a whole.
c. At the level of public policies more generally, beyond climate policies in a narrow sense

   - Is the climate policy instrument mix well-integrated with other (political, socioeconomic) framework conditions, as defined by other sectoral polities – such as energy policies or social policies?
   - Does the climate policy instrument mix strike an optimal balance between avoiding climate change (=mitigation) and preparing for the unavoidable impacts (=adaptation, geoengineering)?
   - Does the climate policy instrument mix maximise social welfare, i.e. does it respond to the preferences of all economic actors (or could welfare be enhanced by re-allocating resources from climate policies to, e.g., education, healthcare or general consumption?

d. At the spatial level:

   - How optimal is the division of efforts among different EU Member States that is established by the climate policy instruments; and how efficient is the division between national-level and EU-level climate action?
   - How optimal is the global division of labour in terms of mitigation efforts – how "optimal" can EU climate policy be if other major emitters do not pursue comparable efforts?

While each of these angles is valid and relevant, it would overstretch the limits of most research projects to cover all of them. The focus of the CECILIA2050 project is clearly on b), the functioning of the climate policy instrument mix as a whole, and the interaction between different policy instruments. This will be done for four broad areas of climate policy (policy landscapes), namely carbon pricing, support for renewable energy, energy efficiency and non-CO_2-greenhouse gases, and for European climate policy (i.e. EU and national-level mitigation policies) as a whole.

Other than that, the project will also address some aspects of the other questions raised. This includes a), the functioning of individual policy instruments, insofar as the performance of the policy mix as a whole cannot be discussed without understanding the performance of its components. While the CECILIA2050 project does not aim to provide detailed evaluations or recommendations for individual policy instruments, there may be instances where the performance of the policy instrument mix as a whole could be enhanced substantially by changes to one of its components, notably the fine-tuning between the EU ETS and other instruments.

In this spirit, the CECILIA2050 project will also touch upon the first aspect of c) above, i.e. the integration of the climate policy instrument mix into the wider policy landscape and the consistency thereof, recognising that climate policy has become inseparably linked in particular to energy policies. It will also look at d), the assessment of European policies in comparison and in relation to climate policies abroad. The project will not discuss in any great detail the second and third aspects of c), i.e. the trade-off between mitigation and adaptation, or between climate policies and other policy areas, since the project takes the European climate targets and the decarbonisation agenda as a given point of reference.

A further distinction that can be made for an assessment of policies is the temporal angle. The optimality of a given (set of) policy instrument(s) can be assessed at different points in time:

a. In the planning stage, before a policy is implemented (ex-ante): at this stage, an assessment is only possible based on the proposed instrument design and its projected / expected performance.

b. After a policy has been implemented (ex-post), and as the impacts of the policy are becoming / have become visible.

The CECILIA2050 project combines both ex-post and ex-ante, through its backward-looking and stocktaking component and the forward-looking component. In principle, the ideas about the optimality of policy instruments described above apply both to the ex-ante and the ex-post analysis, and hence same assessment criteria will be used. Arguably, though, the aspect of feasibility (in particular political feasibility) lends itself more to an ex-post analysis. Obviously, all the policy instruments that are in existence today have proven to be political, legally and administratively feasible (else they would not exist). Yet, the analysis of feasibility can help to explain some of the decisions that were taken during the choice, the design and the implementation of a policy instrument, which will eventually determine its performance in terms of effectiveness and efficiency. An ex-ante analysis of feasibility is possible (as in discussing the factors that make it more or less likely that a policy is implemented, and performs as planned); yet faces the difficulty of anticipating the social and political dynamics that lead to the adoption or rejection of a particular instrument. Possibly, some of the discrepancies that are regularly found between ex-ante and ex-post analyses are due to the fact that problems of political feasibility of policy proposals are not fully anticipated, and only emerge during the implementation process. Nevertheless, this poses the interesting challenge how the feasibility limits that are observed ex-post can be better anticipated in the ex-ante design of climate policy instruments.

7 Conclusions and the Way Forward

This document provides a working definition of optimality for the purposes of the CECILIA2050 project – which may need to be revised an updated in light of the subsequent project results.

This document also described some main elements that characterise the unique approach of the CECILIA2050 project, in particular:

- **Feasibility of policies** – what changes in the assessment of a policy's qualities when real-world constraints are incorporated? Clearly, policies are never adopted and implemented as they were planned, as they need to respond to multiple constraints – compatibility with existing law needs to be ensured, limited administrative capacities considered, opposition from stakeholders overcome, lobbying and rent-seeking behaviour addressed. Some proposals never make it past the drawing board, others are implemented, but are littered with exemptions and derogations, which affects both their efficiency and effectiveness, and may turn a relatively simple instrument into a bureaucratic monster. The question is how such constraints can already be anticipated in the policy design – how can policies be designed robust enough to secure political support and withstand rent-seeking, to tie in neatly with pre-existing legislation, and to achieve all that at a reasonable administrative burden.
- **Policy mixes** – It is not isolated policy instruments that matter, but ultimately the performance of the policy mix as a while, including the interaction with the wider policy framework. How well are the existing climate policies aligned, and do they complement or contradict each other? Where policy instruments overlap – is this overlap a cause of inefficiency, or does it provide an insurance against policy failure? The question of policy coherence extends beyond environmental / climate policies proper: for instance, does R&D policy provide the right framework and incentives to trigger the radical innovations that are necessary across key sectors (such as energy, transport, housing) – something that climate policies are not well-disposed to achieve. Are complementary policies in place to overcome structural barriers to climate policies, particular in the network industries – such as learning costs and access to finance?
- **What role for optimality?** The idea that there is a single, optimal policy mix to guide Europe's transformation to a low-carbon economy, and that, with enough empirical research, this policy mix can be identified, seems overly ambitious. It seems more

useful to conceive of optimality as an ongoing search process, which can respond to new information – new insights on climate change and its effects, technological developments, as well as societal changes. To manage and direct this process, policies need to deal with risks and uncertainties, with strategic behaviour, hidden agendas and incomplete knowledge. In order to respond to new information and changing circumstances, the process will need to remain flexible, and yet give a clear and credible signal to stimulate the necessary R&D efforts and investments.

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Annex I: Taxonomy of Policy Instruments

This annex lays down a taxonomic and terminological framework for discussions of policy instruments in the CECILIA2050 project. There is a range of literature on the classification of policy instruments into different categories (see e.g. de Serres et al. 2010, Duval 2008, Goulder and Parry 2008, Hatch 2005, Hood 2011, Oates and Baumol 1975, Sorrell et al. 2003). The following taxonomy is based on a literature review and verified by discussions in the CECILIA2050 consortium.

Starting with the definition of a policy instrument, Sorrell et al. (2003: 14) argue that instruments establish rules and influencing mechanisms, through which the rule-making authority stimulates a certain behaviour of the target group, in order to achieve one or more specified objectives. The change in behaviour can be achieved by "imposing obligations on the target group(s), creating incentives for the target group(s), and/or enhancing the capacity of the target group(s)".

An alternative approach is to tie the definition of a policy instrument to the legal act that establishes the instrument. In this vein, Sorrell et al. (2003: 15) define a policy instrument as a piece of "legislation, law, regulation, initiative etc. that has been introduced by a governing body to address a particular problem and achieve one or more specified objectives." While this legal definition offers the benefit of tying the instrument to a clear basis, it may create complications in practice: Climate legislation, e.g. in the EU, will often include a suite of policy instruments (with distinct, separate and independent influencing mechanisms), which are combined into one piece of legislation to form integrated policy packages. Alternatively, climate legislation may take the form of a framework laws that can accommodate a range of different instruments, often left to the discretion of the implementing authority. At the same time, the opposite may also be the case: one single policy instrument will often be implemented through a whole suite of laws and regulations, which regulate different aspects of what is essentially the same policy instrument, i.e. working through one common influencing mechanism.[13] For this reason, while the legal basis of a policy instrument is clearly relevant for a number of aspects (such as defining the target groups and policy objectives, to begin with), it does not seem practical to link the definition of a policy

[13] The EU Emissions Trading Scheme being a case in point: While the EU Emissions Trading Directive (Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community) defines the basic rules of the ETS, the main directive is complemented by further directives on the inclusion of aviation (Directive 2008/101/EC), and on linking to the project-based mechanisms under the Kyoto Protocol (Directive 2004/101/EC). The system is implemented through a suite of regulations including on Monitoring and Reporting (Commission Regulation 601/2012), Verification and Accreditation (600/2012), on the ETS Registry (Commission Regulations 920/2010 and 1193/2011), on Allowance Auctioning (Commission Regulation 1031/2010), as well as a range of Commission Decisions on particular aspects of the scheme.

instrument too closely to the legal basis. Instead, the definition should retain a clear focus on the influencing mechanism that an instrument establishes to achieve its objective.

A further complication is that many policy instruments, especially larger and more complex ones, will often combine different elements under one scheme. For instance, an emissions trading mechanism (a flexible, market-based tool) will be complemented by reporting obligations and penalties to ensure compliance (which are more reminiscent of command-and-control instruments). The key distinction here is whether these complementary provisions are merely secondary tools to support the primary influencing mechanism of the policy instrument (as is the case for monitoring and reporting provisions under a trading scheme), or whether they establish a separate influencing mechanism, which contributes to the policy objective independently of the main instrument.[14]

Two useful distinctions for structuring and classifying policy instruments are the actors, and the strength of the intervention that instruments exercise.

- In terms of actors, instruments can apply at different levels of governance, including supra-national (international, EU), national and sub-national (provinces, municipalities). There will often be a hierarchy among these levels, e.g. an instrument may be described in general terms in international law, which are implemented in a (framework) Directive at EU level, which is transposed into national legislation and ultimately administered by a government agency at the sub-national level. Beyond state actors, policy instruments may also be applied by way of self-regulation among the emitters, e.g. in the context of voluntary agreements at industry level, often in order to pre-empt and avoid mandatory regulation by the government.
- The strength of an intervention depends on the degree of prescription, i.e. to what extent does an instrument determine the level, type and method of environmental improvement, and the degree of coercion, i.e. to what extent does an instrument exert negative pressure on the regulated party (Gunningham et al. 1998). In other words, the strength of an intervention describes how much freedom a policy instrument leaves to the regulated parties to chose their own response, and how much it binds them to a particular course of action.

The following figure provides an overview of the taxonomy of instruments, which are further explained in the following. At the most aggregate level, the instruments are classified into two main categories:

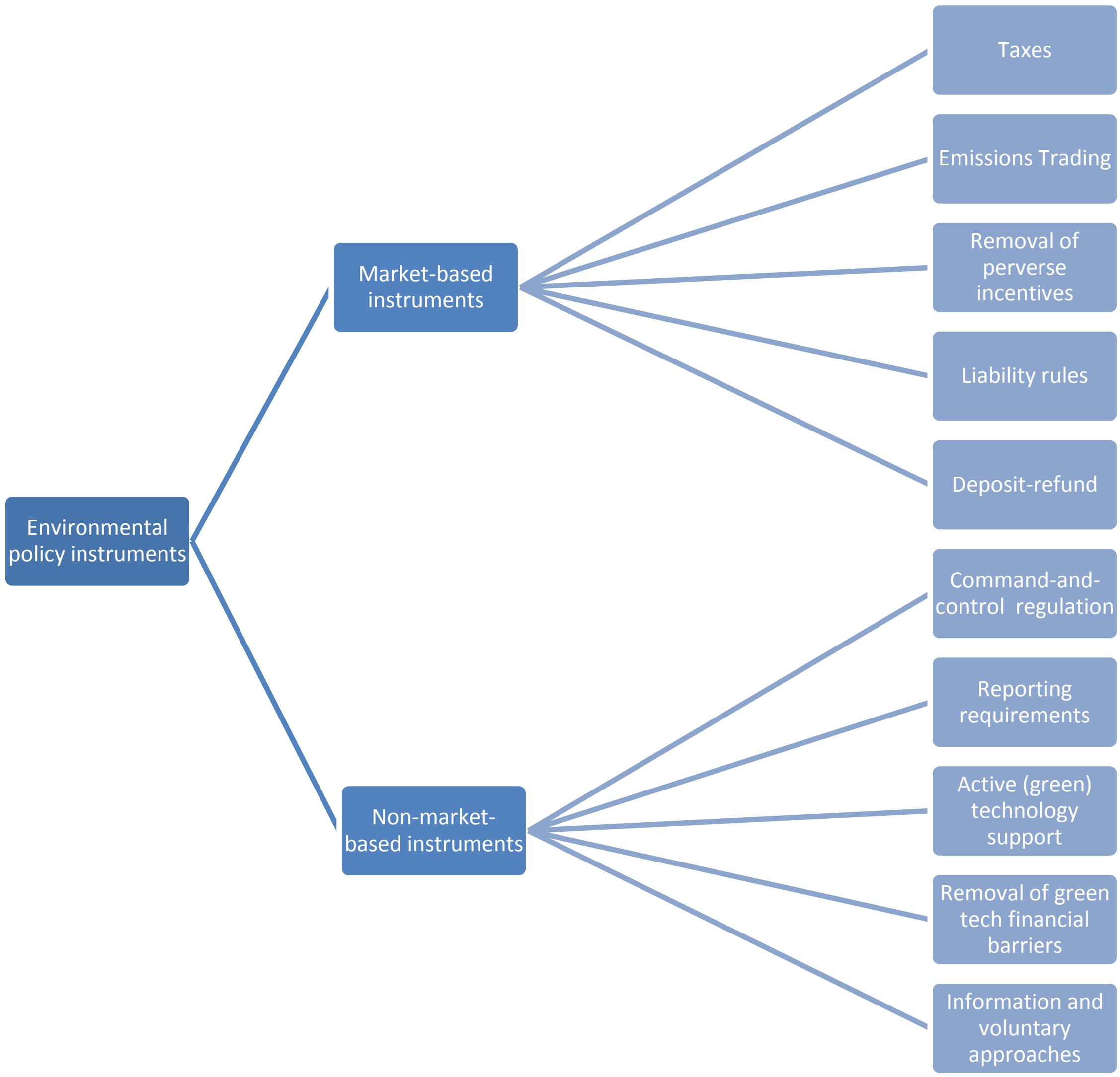
- **Market-based instruments:** Market-based instruments are policies that address market externalities by "closing the (welfare-reducing) gaps between private and

[14] An example of the latter could be seen in the provision of the EU ETS Directive (Article 10a (7)) to set aside 300 million emission allowances specifically to support the construction of demonstration projects for the capture and storage of CO_2 (CCS).

social costs (and/or benefits) [of private actor-driven] market activities"[15] Market-based instruments incorporate the external costs of production or consumption in the price. They are also referred to as economic instruments.

- **Non-market-based instruments**: all instruments that do not work through changing prices, but by imposing obligations (command-and-control) or by encouraging / discouraging certain behaviour through non-monetary incentives.

Figure 1 A taxonomical overview of environmental policy instruments



[15] de Serres, Murtin, Nicoletti (2010)

1 Market-based instruments

1.1 Taxes

1.1.1 Taxes directly applied to the pollution source (Carbon Tax)

In principle, the most straightforward way of internalising the external cost of greenhouse gas emissions is to impose a tax on the actual emissions. The most common form of a GHG emissions tax is a carbon tax, which can be extended to include CO_2-equivalents for other greenhouse gases. In this case, the carbon price is stated and fixed through the regulation that introduces the text, but the amount of emissions reductions achieved by the tax remains uncertain. The main drawback of a tax on actual greenhouse gas emissions is that the taxpayers need to monitor and report their actual emissions.

In the field of climate policies, there are only few examples of a direct tax on CO_2 emissions, found in Norway and Aragon (Spain) (de Serres et al. 2010, 15).

1.1.2 Taxes on inputs or outputs of a production process

A more common option for climate taxes is to base the tax on inputs or outputs of a production process, which avoids the necessity to monitor actual emissions. Taxes on inputs or outputs of a production process are prominent in the transport sector (de Serres et al. 2010). The most common example, which is found throughout OECD countries, is a tax on (mineral) fuels. If based on the carbon content on fuels, it is in fact equivalent to an emission tax, assuming that the sold fuels will eventually be combusted and then lead to emissions. Alternatively, taxes can also be based on the product, unit or installation that emits greenhouse gases (e.g. vehicle registration taxes differentiated according to fuel efficiency), or on the activity that gives rise to emissions (e.g. climate taxes imposed on airline tickets). If the main objective is that the tax should internalise the external costs of greenhouse gas emissions, it is preferable to base the tax on fuel consumption or on actual emissions.

1.1.3 Financial support mechanisms for climate-friendly products and activities

Financial support mechanisms for climate-friendly products and activities can take different forms, such as differential tax rates, or direct support schemes (direct payments, subsidised loans). Either of these encourages a switch towards activities that cause smaller or no externalities. A differential tax rate can take the form of a partial tax exemption (reduced tax rates), to a full tax exemption (or tax break), to negative taxes (or subsidies per unit of consumption).

Examples of differential tax rates include differential VAT rates for very energy-efficient products, as well as lower fuel taxes or full fuel tax exemption for biofuels. Examples of direct support schemes include direct payments or subsidised loans for homeowners who improve the energy efficiency of their homes.

1.2 Emissions trading systems

1.2.1 Cap-and-trade

Cap-and-trade systems have an overall limit on the amount of a particular pollutant (de Serres 2010). A central authority sets this limit. Permits are allocated to entities whose activities contribute to emissions according to different rules and conditions.

Examples include the EU emission trading scheme (ETS), NO_x and SO_2 emissions trading schemes in the US, Canada (NO_x), Netherlands (NO_x), Slovakia (SO_2) and Switzerland (NO_x), and cap-and-trade systems in water management, fisheries, and agricultural nutrients. Cap-and-trade systems are different from credit systems because they set a fixed ceiling on emission amounts whereas credit systems set a floor or "minimum performance commitment" on this quantity.

1.2.2 Baseline-and-credit systems

Credit systems impose a minimum performance commitment relative to some (pre-set) baseline profile of emissions. A regulator sets the baseline for each participant in this system and the regulator monitors actual emissions accordingly. Participants then "claim credits" based on their emission reductions after they achieve the relative baseline. They then can sell their excess emissions reductions. Unlike cap-and-trade systems credit systems do not set a fixed ceiling on emission amounts.

Examples include the Clean Development Mechanism (CDM) under the Kyoto Protocol and the 1980s initiative in the U.S. to reduce lead content in gasoline.

1.3 Removal of perverse incentives

1.3.1 Removal of environmentally harmful subsidies

Subsidies to environmentally damaging activities and products are a common feature in many countries world-wide. Developed countries tend to subsidise the production / extraction of fossil fuels (through payments to producers), whereas many developing countries and economies in transition subsidise the consumption of fossil fuels by keeping prices artificially low. Removing the "perverse incentives"

Examples include removing coal production subsidies.

1.3.2 Correction of other incentives

This includes changes in other incentives that support or reward damaging activities, such as corrections to the liability framework, where exemptions from liability or incomplete liability rules constitute an implicit subsidy and distort competition.

1.4 Liability instruments

1.4.1 General liability rules

Liability instruments impel concerned parties to internalize external costs through the threat of consequential costs (Sorrell 2003). Liability instruments do not completely cease potentially environmentally harmful activity, but rather reduce environmentally consequential actions.

Differences in degrees of severity for liability exist. For example, strict liability requires the responsible entity to pay for damage even if the corresponding firm took all required precautions without any proof of carelessness or fault.

Examples include non-compliance fines or the cost liabilities tied to potential accidents in a nuclear power plant.

1.4.2 Adapting liability rules in dependence of environmental impact

Reducing the liability requirements for environmental friendly activities supports the deployment. Increasing the liability polluting activities beyond the general rules can reduce the environmental impact by reducing the optimal level of pollution achieved by the pollutant.

1.5 Deposit refund systems

Deposit refund systems are a charge for the disposal of a consumer product combined with a subsidy for returning it to a specific collection point. The deposit can be considered as an upfront payment for the costs of improper waste disposal. The refund serves as a reward for proper waste disposal.

Examples include containers of beverages of hazardous product, and lead-acid batteries.

2 Non-market based instruments

2.1 Command and control regulations

2.1.1 Framework standards

Framework standards are qualitative requirements, which require performance interpretation.

Examples include BATNEEC (best available technology not entailing excessive cost) and ALARP (as low as reasonably practicable).[16]

The Framework standards can also include requirements for operating certification. Operating certification requirements create a standard for firms and individuals to heighten performance standards and limit individual exposure to environmental risk.

Examples include HFC handling certifications.

2.1.2 Performance standards

Performance standards set specific environmental targets for concerned parties without mandating particular technologies. Examples include fleet average CO2 vehicle efficiency, total material requirement targets (TMR), and limiting the amount of emissions per unit of output (Perrels 2001).

Alternative names: "benchmarks", "minimum energy performance standard" (MEPS)

Examples: Ecodesign Directive, Front Runner approach

2.1.3 Technology standards

Technology standards impose "specific abatement technologies on emitters" (Duval 2008, 21). Operators are uniformly required to use a specific technology. Technology standards can be implemented with ease in a lot of emission reduction technology production processes. Technology standards force operators to use a specific product. In comparison performance standards set targets without mandating specific technologies or products as it is the case here.

Examples include German FGD legislation

Alternative name: "end-of-pipe technologies"

2.1.4 Prohibition or mandating of certain products or practices

This refers to "bans on certain products or practices" or "obligations to obtain special permits and control-certificates for operations involving specific products" (de Serres 2010, 24).

Examples include the Montreal Protocol ban on CFCs

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[16] http://www.epa.ie/whatwedo/advice/bat/

2.1.5 Building codes and standards

Building codes and standards set environmental targets in the construction of buildings. Similar to performance standards but focused on the building sector.

Examples include the Building Energy Regulation in Germany (EnEV)

2.1.6 Land use planning, zoning

Land use planning and zoning set specific environmental targets in how land is used without choosing the technology that will be used in the planned space.

2.2 Stand alone Reporting requirements

2.2.1 All

Stand-alone reporting is usually the first step to a future regulation and required to increase the information level in the administration. Also the creation of an emissions inventory is a reporting requirement

Reporting requirements are usually part of instruments other instruments as standards or ETS.

2.3 Active technology support policies

Active technology-support policies are created to promote the “development and deployment of technologies” (de Serres 2010, 24). They accomplish this through R&D or adoption incentives. The emphasis in active technology support policies is on directly acting on supply and not relying on environmentally friendly demand (de Serres 2010).

Examples include public investment in environment-related R&D, public funding for private R&D, public procurement to foster green activities, green certificates and feed-in tariffs (de Serres 2010).

Alternative names: “green technology-support policies”

2.3.1 Public and private RD&D funding

Public and private RD&D fit a range of possibilities of investment, which may extend from investing in basic public research to direct government funding of private R&D and tax incentives.

2.3.2 Public procurement

Public procurement refers to public adoption of policy instruments, which sets a standard of product or instrument usage in the process of public procurement.

2.3.3 Green certificates

Green certificates refer to renewable energy certificates. Each certificate represents the certified generation of one unit of renewable energy, generally one megawatt-hour (MWh).

Certificates can be traded and used to meet renewable energy obligations among consumers and/or producers, and can also be used for voluntary renewable energy power purchases.

Alternative names: "tradable permit"

2.3.4 Renewable portfolio standard

Renewable portfolio standards require a minimum percentage of electricity sold or generation capacity installed to be provided by renewable energy, which utilities must meet. They can also set obligations that a minimum percentage of electricity purchased comes from renewable energy sources (IEA 2010).

Alternative names: "quota policies" "clean energy standard" "carbon price substitute"

2.3.5 Feed-in tariffs

A feed-in tariff is a policy instrument, which gives a fixed guaranteed price at which power producers can sell renewable power into the electric power network (IEA 2010). The tariff can be adjusted in accordance to the current electricity price but must guarantee a minimum price for each kWh generated over a certain period of time.

Examples include the German Renewable Energy Act (EEG).

2.3.6 Public investment in underpinning infrastructure for new technologies

Public investment in underpinning infrastructure for new technologies entails a governmental body including new technologies in current or future public investments.

2.4 Financial measures (subsidies)

2.4.1 Policies to remove financial barriers to acquiring green technology

Policies to remove financial barriers to acquiring green technology are financial instruments, which mobilize financial resources for the explicit purpose of environmental protection (Sorrell 2003).

Examples include UK capital allowances for investment in energy efficient equipment, sponsored loans or tax breaks for energy efficient buildings

Alternative names: "financial instruments," "fiscal instruments," "tax breaks," "loans," "revolving funds"

2.5 Information and voluntary approaches

Information and voluntary approaches use instruments that then "improve consumer awareness" about environmental impacts of products and practices and give information about the availability of less damaging alternatives (de Serres et al. 2010, 24). Their purpose is to facilitate better-informed consumer decision-making (de Serres et al. 2010). Examples include the *Pollutant Release and Transfer Registers*.

2.5.1 Education and training

Education and training policy instruments correct a "lack of information" for consumers by building the capacity to respond by appealing to consumer values and/or attempting to modify values (Sorrell 2003, 19).

Examples include corporate environmental reporting; "community right to know," pollution inventories (e.g. US TRI).

2.6 Product certification and labelling

Product certification and labelling refers to the usage of a label or symbol indicating that compliance with specific standards has been verified. Use of the label is usually controlled by a standard-setting body (Dankers 2003).

Examples include the U.S. Green Building Council's LEED certification.

2.6.1 Environmental labelling programs

An environmental labelling program is the practice of labelling products based on a wide range of environmental considerations (e.g. hazard warnings, certified marketing claims, and information disclosure labels, EPA 1998).

A Type I environmental labelling program is a voluntary, multiple-criteria based, third party program that awards a license which authorizes the use of environmental labels on products indicating overall environmental preferability of a product within a product category based on life cycle considerations (Global Ecolabelling Network 2004).

Examples include the Environmentally Friendly Label (Hungary), Blue Angel (Germany)

Alternative name: "ecolabelling"

A Type II environmental labelling program is a self-declarative form of voluntary environmental performance assessment. A third party does not evaluate the product or service (Global Ecolabelling Network 2004).

Type II environmental labelling programs are voluntary programs that provide quantified environmental data of a product, under pre-set categories of parameters set by a qualified third party and based on life cycle assessment, and verified by that or another qualified third party (Global Ecolabelling Network 2004).

Examples include the EPD.

2.6.2 Award schemes

Award schemes are a form of public recognition from public authorities recognizing environmental performance achievement based on a set of criteria set by the awarding body. Award schemes can exist at both national and supra-national levels.

Examples include the European Business Awards for the Environment.

2.6.3 Public information campaign

Public information campaigns entail public actors raising awareness within adult populations about environmental policy initiatives or concerns.

2.6.4 Voluntary agreements

Voluntary approaches are negotiated agreements between the government and particular industrial sectors to address a specific environmental concern (de Serres 2010). The level of stringency, monitoring and sanctions varies among these agreements. Their purpose is usually to “forestall or deflect the introduction of more direct approaches” (de Serres 2010, 25).

Alternative names: “negotiated agreements between industry and public authorities”

2.6.5 Unilateral commitments

Unilateral commitments are voluntary policies, which firms or industry groups undertake and self-initiate to abate pollution or tackle another environmental problem (Wuppertal Institute).

Examples include the Responsible Care Program and the 1995 German Declaration of Industry on Global Warming Prevention.

2.6.6 Public voluntary schemes

Public voluntary schemes entail a voluntary adoption of standards, procedures, targets, etc. which public bodies developed.

Examples include the EU Eco-management and Audit Scheme (EMAS), the UK’s “Making a Corporate Commitment Campaign” and the US Green Lights program