

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

Pathways for the evolution of climate policy instruments



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AUTHORS

Luis Rey, BC3;

Mikel Gonzalez, BC3

Anil Markandya, BC3

With thanks to:

Benjamin Görlach, Ecologic Institute

Pau Drummond, UCL

Galt Hupples, CML

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1 Introduction

The objective of stabilizing climate “at a level that would prevent dangerous anthropogenic interference with the climate system” (UNFCCC 1992) means that global temperatures should not rise more than **2°C** above pre-industrial levels, as stated by the United Nations in the Cancun Accords According to the Intergovernmental Panel on Climate Change (IPCC 2007, 2013) this objective will require greenhouse gas concentrations to be limited to around 450 ppm CO₂-equivalent, and for that to happen global GHG emissions will need to be reduced by around 50% by 2050 (compared to 1990) and more than 80% by 2100.

Meeting this global target requires considerable emission reductions in high-income countries, but also early involvement of developing countries. If a gradual convergence in emission per capita would be the criteria selected for the **regional distribution of the burden**, then, high-income countries will have to reduce emissions by around 80-95% for 2050.

In the case of the European Union (EU), the European Council confirmed in February 2011 the **EU objective of reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990**. In order to meet this target, and at the same time stimulate economic growth and ensure competitiveness of the EU, the European Commission presented a Roadmap (EC 2011, Roadmap for moving to a low-carbon economy in 2050,) for possible action up to 2050, bearing in mind that the reduction objective in the EU will largely need to be met internally. The document sketches how to deliver this target in a cost-effective manner and outlines general milestones for 2020, 2030 and 2050 and also specific milestones by sectors.

In order to understand the immense challenge that EU faces, the Table 1 shows the **cost-efficient pathway**, according to the models, towards the 2050's objective. The emissions should be internally reduced by 40% in 2030 and by 80% in 2050. According to this document with the current policies, emission would be reduced just by 30% in 2030 and by 40% in 2050. Table 2 also shows the cost-effective distribution of the reduction by sectors. The reduction required shows that some sectors such as the power sector will need have a radical change, as they should be almost free of GHG emissions by 2050. In fact, and in order to be cost-effective, the investment decision for the decarbonization of these sectors should be made not later than 2020-2030, if a life-time of 30-40 years of these infrastructures is considered.

Recently, the European Commission and the European Parliament are discussing the **climate and energy objectives for 2030**. The European Parliament voted in February 2014 to require MS to meet binding national targets on renewable energy, energy efficiency and GHG emissions for 2030 that included: a 40% cut in GHG, compared with 1990 levels; at least 30% of energy to come from renewable sources; and a 40% improvement in energy efficiency. These targets are different than the proposal from the European Commission that called for a target of 27% of energy to come from renewable sources at EU level, without binding national targets. Moreover, under the Commission's plan, there was no target for energy

efficiency. In any case, it seems that the new GHG emissions reduction target will a bit lower than the cost-effective path suggested in the Roadmap.

Table 1. EU global cost-efficient pathway towards the 2050's objective

	2020	2030	2040	2050
Cost-effective pathway	20%	45%	60%	80%
Current policy pathway	18%	28%	35%	40%

Source: EC (2011)

Table 2. EU sectorial cost-efficient pathway towards the 2050's objective

	2030	2050
Power (CO ₂)	-54 to -68%	-93 to -99%
Industry (CO ₂)	-34 to -40%	-83 to -87%
Transport (incl. CO ₂ aviation, excl. maritime)	+20% to -9%	-54 to -67%
Residential and services (CO ₂)	-37 to -53%	-88 to -91%
Agriculture (non-CO ₂)	-36 to -37%	-42 to -49%
Other non-CO ₂ emissions	-72 to -73%	-70 to -78%

Source: EC (2011)

These targets, especially the 2050's target, can be achieved in theory, but **there is an important gap between the feasibility showed by the models and the instruments that are needed in the real world**. For example, according to the POLES model (Markandya et al 2014), the target is feasible, but with a price on CO₂ that goes from around 100 € per ton of CO₂ in 2020 to around 400 €/tCO₂ in 2050. This price represents a situation where there is an international climate agreement, the markets are competitive and cost-effective technologies are deployed. Any market or government failure will increase the costs and there is a lot of uncertainty about the development of some technologies such as, for example, CCS. Moreover, the rise in carbon pricing will increase considerably the price of energy and electricity, and this will undermine its public and political acceptance. Additionally, it is typically assumed that the necessary infrastructures will be on placed on time, and this may be not the case. According to the EC (EC 2011), to meet the 2050 target additional annual investment equivalent to 1.5% of the EU's GDP, or around € 270 billion per year, would be needed on top of current investments and over the next 40 years.

In the real world, policy instruments are not developed or implemented in a vacuum, but within an institutional, legal and political context. There is an urgent need for an

understanding of how the existing policy mix can be further developed and improved so as to ensure that these milestones can be met in the most efficient and feasible manner on the way to the 2050.

This document explores the different choices of policy instruments that the EU could select to drive this change. It defines combinations of instruments that have an a priori plausibility and a reasonable chance of meeting the desired emissions targets. This includes new options to complement the policy mix, and scaling up current measures at levels and over jurisdictions that have not been attempted so far. Policy pathways cannot be separated from the different directions of governance at the EU level and at the global level (Huppes and Huele, 2014). Consequently, section 3 analyses each policy package in a context with more or less political integration within the EU. It also considers each package in a scenario with or without international consensus to take meaningful climate actions. Section 4 evaluates each package from the point of view of its effectiveness, efficiency and political, administrative and legal feasibility. Additionally it will preliminarily¹ identify the key risks and bottlenecks for the successful implementation and functioning of the instruments packages.

2 Climate policy pathways

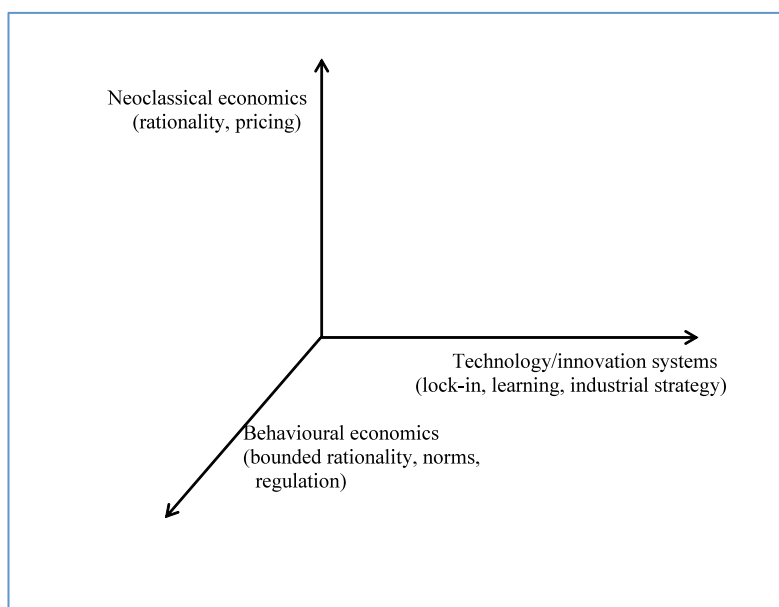
This section defines 3 combinations of instruments that have a reasonable chance of meeting the desired emissions targets by 2030 and beyond. Although all possible combinations should be able in principle to meet emissions targets, they represent different ways to develop current instrument mix. Consequently, each instrument package has advantages and disadvantages. The policy pathways show different options that the EU can select to achieve the targets.

It is important to mention that although each pathway will focus more attention in one type of instruments, all packages should have a certain combination of three policy dimensions to meet the targets, following Stern (2009) and Grubb (2014), see Figure 1. These three dimensions are: 1) Carbon pricing 2) Technology and infrastructure policies (supply-side policies) and 3) behaviour change promotion (demand-side policies). Any successful instrument package should include economic incentives and, therefore, should include a carbon price on emissions. Also given the current dispersion of the implicit and explicit price of CO₂ among instruments, sectors and MS a convergence on carbon price will also be needed. Similarly, an investment programme (that most probably will need to be public) will be needed in order to develop on time some key technologies and infrastructures. Finally, the amount of the change is so huge that some degree of behavioural change will be needed

¹ The legal, distributional, political and other perspectives evaluated in future work packages of CECILIA may suggest that the combinations of instruments of this document are inadequate and need some modification or additions. This means that this document will have to be revisited.

in order to deliver additional abatement. Also a change in the behaviour will be fundamental to promote energy conservation and efficiency and to avoid undesirable rebound-effects.

Figure 1 Three necessary domains of change



Source: Grubb (2014)


Taken all this in consideration, the pathways proposed are the following:

- A. **Market-driven:** In this scenario the key instruments are related with economic incentives. The EU wants to put more main emphasis in the market options (“the markets know best”).
- B. **Technology-specific:** In this scenario the key instruments are related with technology support measures and regulation tools (“government knows best”).
- C. **Behavioural-driven:** In this scenario the key instrument is related to raising consumer awareness are demand-side efforts rather than technical solutions (“austerity is good”).

In the following sub-sections we will analyse in more detail the instruments that will be needed in each scenario in by sectors. Also a sub-section with cross-cutting instruments will be explored.

2.1 Market driven pathway

This policy pathway is based on economic instruments and has a special focus on static efficiency. A carbon price signal is the main driver for emissions reduction and the EU ETS is the key instrument to provide the price signal. The EU ETS is a ‘cap and trade’ system which ensures a certain emission reduction and therefore the environmental objective would be guaranteed. Moreover, by setting a single carbon price, the scheme provides the flexibility to find the cheapest ways to reduce emissions. This implies that static efficiency is also guaranteed. So far, the main weakness of the EU ETS has been the dynamic efficiency. In the



first and second trading periods the EU ETS has not been able to spur innovation in new low-carbon technologies by itself. In order to become the key instrument of the climate policy, the EU ETS should provide a sufficient carbon price signal and long-term predictability. This would require a structural reform of the scheme. A possible solution is to establish a carbon price floor and a price ceiling, with an explicit carbon price objective (EC, 2012), as a bandwidth. This implies a shift from the volume approach to the price approach. Eventually the EU ETS could lead to a carbon tax on the sectors covered.

In those sectors not covered by the EU ETS, other market-based instruments are implemented to reduce emissions (e.g. direct or indirect carbon prices). In order to increase the static efficiency of the policy instrument mix, the price signal should be aligned across sectors and countries. Ideally there is a gradual convergence of carbon prices. This implies that carbon prices in non-ETS sectors should be established in line with the carbon price of the EU ETS.


In addition to current sectors, the EU ETS could be expanded to cover other sectors. This could be simplified with the electrification of the economy. If electricity replaces fossil fuels in transport and heating, a large share of the CO₂ emissions would be covered by the EU ETS. This could also be obtained including other sectors in the scheme (e.g. upstream trading for transport and heating fuels).

The promotion of renewables and energy efficiency is driven by carbon prices and, therefore, non-market based instruments (e.g. feed-in tariff and emission standards) are gradually removed. Alternatively, current national RES support schemes could be replaced by European-wide market-based instruments, such as a system of tradable renewable quotas, which deploy renewables not according to national boundaries, but to natural conditions. In general, only a few other instruments interact with carbon prices. These other instruments are implemented to overcome market failures (e.g. principal agent problem).

Given that emissions reduction is mainly driven by a carbon price signal, this has to be high enough to meet the 2050 objective. Several studies have estimated the required carbon price to reduce GHG emissions by 80% in 2050. Knopf et al (2013) compares 13 models which estimate carbon prices that range from €240/tCO₂ to €1127/tCO₂ in 2050. The median value is €521/tCO₂. In 2030, the median carbon price is €76/tCO₂. The majority of studies find a sudden increase of carbon prices after 2040, to deliver the 80% reduction globally.

The high carbon price required to reduce emissions questions the political feasibility of this scenario. Carbon prices would have a considerable impact on the distribution of welfare and the competitiveness of several sectors.

This pathway assumes technology-neutrality, markets decide. However, electricity could be necessary to replace fossil fuels in transport and heating, if other technologies are not developed (e.g. low-carbon hydrogen). The electrification of the economy would require the development of new infrastructure. The deployment of renewables would be supported by networks and storage systems which ensure the continuity of electricity supply (EC, 2011). Investment in smart grids will be essential to manage electricity demand.



Although government intervention is minimized in this scenario, public investment might be necessary to develop new infrastructure. In order to build the appropriate infrastructure, public institutions have to identify private needs. Public support for R&D will be focused on basic research. Public institutions might consider some technologies as essential (e.g. CCS) and support their development.

- **Energy sector:** the EU ETS is the key instrument in this sector. National energy markets are linked and eventually an EU-wide energy market is established. Other policy instruments are gradually removed particularly renewable support mechanisms. Public support for the development of low-carbon technology is marginal and focused on basic research.
- **Industry:** the EU ETS is the key instrument in industry. Thus, allowance price is the main signal to reduce GHG emissions. Other economic instruments are removed (energy taxes related to CO₂ emissions). In those sector not covered by the EU ETS, direct or indirect taxes are set on energy products. Although international co-operation is assumed, carbon leakage is a potential problem in this sector.
- **Buildings and households:** given that electricity generation is covered by the EU ETS, the main focus is on heating fuels. Higher taxes on heating fuels are set, ideally, in line with the EU ETS allowance price. Some market failures (e.g. principal-agent problem) are not possible to remove with price signals and, therefore, public bodies implement information and regulatory instruments.
- **Transport:** the EU ETS may be expanded to cover transport fuels. This is done at the level of fuel production and imports. Thus, the carbon price for the transport sector is equalised with other EU ETS sectors. In case of the electrification of the transport sector, public infrastructures are developed to make possible this transition. An effective public transport is established to avoid high social costs.
- **Agriculture:** market-based instruments are difficult to implement in this sector. Emissions measurement and monitoring costs are high. This implies that taxes on GHG emissions may not be possible to implement. Therefore indirect taxes or subsidies are set. The current subsidy system is reformed to take into account emissions. A diet change is promoted through taxes on meat consumption based on emissions. According to UNEP (2013) emissions associated with the production of animal-derived protein are ten times higher than those associated with the production of plant-derived protein. Given that agricultural emissions of N₂O mainly derive from the use of nitrogenous fertilizers, nitrogen taxes are one possible instrument (IPCC, 2014).

2.2 Technology-specific pathway

In this pathway public bodies play an important role defining the ways towards a low carbon economy. Technology-support policies are the key instruments to promote the development and deployment of technologies. Renewables and energy efficiency are promoted through these mechanisms. Emission efficiency and technology standards interact with public subsidies and other financial support measures.

The EU ETS remains and covers current sectors. The cap on emissions is set in accordance with the contribution of other instruments. Energy taxes and other indirect carbon taxes

cover non-ETS sectors. The carbon price signal, from the EU ETS and energy taxes, is lower than in the market scenario and, therefore, is not the main driver of emission reduction. In this scenario, the role of price signals is to avoid rebound effects. Energy efficiency gains must not result in a higher energy demand and, hence, price signals are still necessary.

This pathway is characterized by lower explicit carbon prices than in the market scenario. However, technology-support policies such as emission and technology standards will result in higher costs for private companies and households. Moreover, public subsidies and other financial support measures would increase the burden on tax payers. Therefore, although carbon prices are lower, the final cost for the economy can be higher, especially if governments promote the 'wrong' technology.

The interaction of the EU ETS with technology-support policies may result in low and volatile carbon price signals, because the performance of the latter is difficult to predict. This hampers dynamic efficiency. However, stable technology-support instruments would encourage private innovation in clean technology. Public institutions play an active role on R&D. There is public-private coordination to spur innovation in low carbon technologies. Infrastructures are built by public institutions. Government planning facilitates the identification of required infrastructures.

- **Energy sector:** the EU ETS remains as the main economic instrument but it is complemented with intensity standards for power plants. Renewable support schemes remain as a key instrument, and they are gradually integrated in an EU-wide energy market. There is a strong support for key technologies by the EU.
- **Industry:** energy efficiency standards are the key instrument. Regulation may result in higher production costs. Hence, in order to protect domestic industries from foreign competition, there are public subsidies to implement low-carbon technologies. Public support for innovation in low-carbon technologies is also important. The EU ETS remains as the main economic instrument.
- **Buildings and households:** new buildings are constructed according to standards and codes. For old buildings, programmes for refurbishment are implemented. These programmes are supported by public institutions. Appliances are also subject to energy standards and there are programmes to replace old inefficient appliances. Energy taxes give a price signal and are high enough to avoid rebound effects. There is public support for innovation in low-carbon technology.
- **Transport:** emission standards for new vehicles and strong support for low-carbon technologies (e.g. hybrid and electric vehicles) are the key measures in this sector. Public infrastructures are developed to make possible the implementation of new technologies. An effective public transport is established to avoid high social costs. There is a modal shift for freight transport, which is also supported by public infrastructures. Fossil fuel taxes remain to avoid rebound effects.
- **Agriculture:** some technological options are established in this sector. Emissions are reduced by setting particular fertilizers for specific locations. The use of 'enhanced efficiency fertilizers' is promoted. Technology standards for manure management are also established. Most of these measures are costly and, therefore, require financial incentives for farmers.

2.3 Behaviour-driven pathway

In this pathway emission reduction is mainly driven by a behavioural change of households and companies. The role of policy instruments is to encourage and facilitate the shift to a low-carbon lifestyle, foster different initiatives and coordinate them. Therefore, the key instruments in this pathway are those which increase public awareness about climate change, facilitate the adoption of clean initiatives and coordinate them.

Individual awareness is promoted through information and education campaigns which induce the population to reduce energy consumption and improve energy efficiency. Both households and companies benefit from lower energy consumption and, thus, lower energy bills. Individual awareness also encourages the promotion of renewables, even when they are more costly than conventional fossil fuels. Policy instruments, such as subsidies to purchase low-carbon technologies, are implemented to facilitate individual initiatives.


Information campaigns and labelling programs correct a lack of information about the carbon footprint of products and practices. This encourages companies to improve emission efficiency and, thus, reduce their emissions. Voluntary agreements between the government and particular sectors are also used to reduce emissions. The government implements instruments to coordinate private initiatives.

Although public awareness is the main driver of emissions reduction, carbon price signals are still necessary. The EU ETS remains and covers current sectors. The cap on emissions is set according to the contribution of other instruments. The effectiveness of the key instruments of this pathway is very uncertain, which makes the carbon price of the EU ETS very volatile. Energy taxes are used to cover non-ETS sectors. The behavioural change is not based on high carbon prices and, therefore, these are low. Carbon price signals reinforce the behavioural change driven by information and voluntary approaches.

Instruments for the promotion of clean technology are also necessary, especially to remove financial barriers. High investment costs could hamper the adoption of clean technology and, therefore, public subsidies might be necessary.

This scenario is characterized by high uncertainty and low carbon prices. Therefore the incentives for private R&D are low. Public support for innovation is required. New infrastructures are built by public bodies to facilitate the behavioural change of consumers and companies. This can be particularly important in the transport sector, where a more efficient public transport should be developed.

- **Energy sector:** households are informed about the environmental impact of energy products through information campaigns and labels. Public subsidies facilitate the acquisition of clean technologies by households and companies, which increase energy efficiency. This reduces the demand for carbon intensive energy products. The EU ETS remains, but the lower demand for carbon intensive energy sources reduces allowance price. This would require a structural reform of the scheme. A possible solution is to establish a carbon price floor to avoid rebound effects. Citizens' awareness also affects investment decisions. Clean initiatives become more attractive for investment funds, while they stop investing in fossil extraction. Local investment in



energy supply and energy autonomy increase. Governments promote and coordinate these local initiatives.

- **Industry:** voluntary agreements between the government and particular industrial sectors facilitate the adoption of standards, procedures, targets, etc. Corporate social responsibility, transparency and emission accounting play an important role. Consumers' awareness reduces the demand for carbon intensive products. Industrial products are labelled to inform consumers about their environmental impact. The EU ETS remains but a structural reform is carried out to avoid rebound effects.
- **Buildings and households:** most of the measures are focused in this sector. There are public information campaigns to increase households' awareness about environmental impacts of consumption goods and services. There are labelling programs which inform consumers about environmental impacts of products. Information and environmental awareness make households consume low-carbon products and increase energy efficiency. Behavioural change comes from environmental awareness and information, and energy taxes (or carbon taxes) are maintained to avoid rebound effects. In any case, economic burden on households is low. There are public subsidies for refurbishment of existing buildings and purchase of low-carbon appliances.
- **Transport:** this is another key sector in this pathway. Emission reduction is driven by a modal shift. In passenger transport, an efficient public transport is developed. In cities, walking and cycling are the first choice for short distances. A new urban planning facilitates walking/cycling and reduces the need for commuting. Governments also facilitate and coordinate the deployment of new clean technologies such as electric vehicles. Freight transport is affected by a change in consumers' preferences towards local and regional products. There is also a modal shift in freight transport. Road transport is partly replaced by rail and water transport. Efficiency standards and fuel taxes continue in line with current policies.
- **Agriculture:** information campaigns to increase consumer awareness about the emissions associated with food intake. There is a change in the diet of households, which reduces the intake of animal derived food, especially that derived from ruminants. Food waste is reduced through public awareness about the importance of not wasting food and improved food labelling. Emission reductions could be also obtained improving production process. The application of the right amount of nutrient sources would reduce N2O emissions. This is achieved through education and training measures to farmers.

Table 3. Main characteristic of climate policy instrument pathways

	A. Market-driven	B. Technology-specific	C. Behaviour-driven
Philosophy	“The market knows best”	“Regulator knows best”	“We must change our ways”
Storyline	Economic instruments are promoted. Taxes are harmonised and markets linked across EU.	Reliance on technology support measures, directed R&D, codes and standards, and planning tools. Strong focus on stimulating technological innovation.	Measures to raise consumer awareness are promoted. Mobilisation for demand-side efforts rather than technical solutions. Keep the economic burden on households as low as possible.
Key instruments	ETS extension, CO ₂ taxes and basic R&D	Codes and standards, FIT, directed R&D	Information, Voluntary Agreements and promotion of energy efficiency
Performance and Risks	Policy mix would be likely to achieve the objective, but political acceptability of the policy remains uncertain (dynamic efficiency depending on whether the policy signal is seen as credible), risk of policy failure.	Policy mix in principle able to achieve the objective, but technological uncertainty is high – high risk that the regulator will pick the wrong technologies, resulting in high cost burden	Difficult to anticipate the effectiveness of the policies (mixed effects on behavioural changes, rebound effects, working against market price signals etc.), risk of missing the emission target

Table 4. Sectorial disaggregated climate policy instrument by pathways

	A. Market-driven	B. Technology-specific	C. Behavioural-driven
Energy sector	<ul style="list-style-type: none"> • EU ETS • RES support schemes are gradually removed or replaced by market-based instruments 	<ul style="list-style-type: none"> • RES support schemes • The interaction with other instruments lowers the carbon price of the EU ETS 	<ul style="list-style-type: none"> • Voluntary agreements • EU ETS and RES support schemes
Industry	<ul style="list-style-type: none"> • EU ETS • Some industries are protected from foreign competition 	<ul style="list-style-type: none"> • Technology standards • Public support to implement low carbon technologies 	<ul style="list-style-type: none"> • Voluntary agreements • EU ETS and technologies standards
Buildings	<ul style="list-style-type: none"> • Taxes on energy products not covered by the EU ETS 	<ul style="list-style-type: none"> • Energy efficiency standards 	<ul style="list-style-type: none"> • Public information campaigns
Transport	<ul style="list-style-type: none"> • EU ETS expands to cover transport fuels 	<ul style="list-style-type: none"> • Energy efficiency standards 	<ul style="list-style-type: none"> • Information campaigns. Modal shift

Agriculture	<ul style="list-style-type: none"> Indirect taxes on emissions 	<ul style="list-style-type: none"> Technology standards (fertilizers, manure management) 	<ul style="list-style-type: none"> Diet change through environmental awareness Voluntary agreements with farmers
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Table 5. Cross-cutting climate policy instrument by pathways


	A. Market-driven	B. Technology-specific	C. Behaviour-driven
Role of carbon price signal	It is the key mechanism to promote renewables, energy efficiency and, thus, reduce GHG emissions.	It is used to avoid rebound effects.	The carbon price signal is low and plays a minor role in the reduction of emissions.
R&D	Price signal is the main driver of R&D. Public support for basic R&D.	Technology support instruments promote private R&D. Directed public R&D on specific technologies.	Directed public R&D on specific technologies.
Technology deployment	Carbon price signal is the main driver in the adoption of clean technology.	Technology support instruments encourage the adoption of clean technology.	Financial subsidies are set to overcome market barriers.
Infrastructure	Public institutions build required infrastructure. Private-public coordination to identify private needs.	Public institutions build new infrastructure based on their own criteria.	Public institutions build new infrastructure to facilitate the behavioural change of consumers and companies.

3 Governance scenarios

Governance is not fixed and, consequently, instrument packages are implemented in different governance scenarios, which cannot be controlled. This can affect the plausibility of the instrument packages (see Table 6). This section analyses how the policy pathways described in the previous section could be adapted to different governance scenarios. Two different directions of governance at the EU level and at the global level are considered. First, it is considered the evolution of the EU towards a more or less political integration. And second, it is considered the existence or not of international consensus to take meaningful climate actions. Based on these two dimensions, 4 governance scenarios are obtained: EU centralised with global ambition, EU decentralised with global ambition, EU centralised with global fragmentation and EU decentralised with global fragmentation.

3.1 EU centralised with global ambition

This scenario assumes that the EU climate and energy policy tends to a further centralisation and there is international consensus to reduce emissions globally. This scenario fits well for market-driven instruments (see Table 6). A higher EU centralisation allows applying



instruments EU-wide and exploiting gains from intra-EU trade. The EU centralisation would facilitate the expansion of the EU ETS to cover other sectors and carry out a structural reform, which improves the scheme. EU-wide ambitious taxes also require a strong and centralised EU. The international consensus to reduce emissions decreases the risk of carbon leakage. The high carbon prices that characterize the market-driven pathway would not lead to a lower international competitiveness of domestic industries.

Technology-driven pathway also fits in this scenario. Similarly to the market-driven pathway, the higher costs derived from climate regulations would not reduce domestic competitiveness due to global ambition. Given that all Member States are subject to the same policies, EU-wide regulation also encourages intra-EU competition. The deployment of low-carbon technologies would benefit from the common market.

On the other hand, the instrument package in the behaviour-driven pathway is based on national, sub-national and local policies. Therefore, it does not require a strong and centralised EU. However, a global consensus on emission reduction would increase the individual awareness on climate change and facilitate voluntary agreements between the EU and particular industrial sectors.

3.2 EU decentralised with global ambition

This scenario assumes that the EU climate and energy policy tends to a further decentralisation and there is international consensus to reduce emissions. In the absence of EU-wide markets, the efficiency of market-based instruments is reduced. The EU-ETS could remain, but it should be adapted to this new scenario, moving back from EU-wide cap to country caps. Energy taxes would be set at national level. Different carbon price signals increase the differences between countries in abatement costs and, thus, reduce the static efficiency. This also leads to different production costs across countries, affecting market competition in some sectors. Global ambition allows keeping industrial competitiveness in international markets.

In a technology-driven pathway, the choice of technologies is best determined at the national level. Thus, in this scenario each Member State promotes those technologies that best suit their own circumstances. However, different regulations across countries could jeopardize the common market. The role of the EU should be focused on the coordination of national regulations and promote knowledge sharing.

A behaviour-driven pathway could fit well in this scenario. Global commitment on climate change encourages individual initiatives to reduce emissions. Besides, a decentralised EU does not represent an obstacle for climate policies, which are set at national and local level. National governments promote and coordinate local initiatives. The economic burden on households and companies is lower than in other pathways and, therefore, the common market should not be affected.

3.3 EU centralised with global fragmentation

This scenario assumes that the EU climate and energy policy tends to a further centralisation and there is not international consensus to reduce emissions. In this scenario, the market-driven pathway could work, but it would be necessary to shield EU economy from foreign competition. The carbon price of the EU ETS and other market-based instruments would reduce the international competitiveness of domestic companies. Additional measures such as carbon tariffs would be implemented. On the other hand, as argued above, a strong and centralised EU is in line with a market-driven pathway.

In a technology-driven pathway, the higher costs of regulation cannot result in a loss of international competitiveness. Consequently, the regulation burden cannot fall on those sectors exposed to foreign competition. Policy instruments such as public subsidies to purchase low-carbon technology would spread the cost of climate policies on other sectors. The EU could pick winners, and cooperate with the private sector to develop and implement low-carbon technologies. R&D public funding is essential to reduce abatement costs and make cheaper the transition to a low-carbon economy. When low-carbon technologies become economically attractive, non-EU countries could adopt them.

Neither EU centralisation nor global fragmentation is in line with a behaviour-driven pathway. It would be difficult to increase the individual awareness about climate change when there is not an international agreement. Moreover, behaviour change is best encourage with national and local measures. EU-driven policies would even be counterproductive.

3.4 EU decentralised with global fragmentation

This scenario assumes that the EU climate and energy policy tends to a further decentralisation and there is not international consensus to reduce emissions. This is the worst scenario to implement market-based instruments. As mentioned above, global fragmentation would require measures to protect domestic companies. Without a strong and centralised EU, different market-based instruments across countries would be incompatible with the common market.

A technology-driven pathway could be adapted to this scenario. Each Member State would implement their own strategy to develop particular technologies. The role of the EU should be focused on the coordination of national policies and guarantee equal competition in the common market.

This scenario could be suitable for a behaviour-driven pathway, which implies a lower economic burden on households and companies than other pathways. Although behavioural change is difficult to promote without a global commitment, the lower economic cost of the policy instruments increases the plausibility of this scenario. A decentralised scenario would

benefit the implementation of national and local measures, which incentivise individual initiatives.

Table 6. Plausibility of the policy pathways in different governance scenarios


EU dimension	EU centralised	EU decentralised	EU centralised	EU decentralised
Global dimension	Global ambition	Global ambition	Global fragmentation	Global fragmentation
Market-driven	1	2	3	4
Technology-driven	5	6	7	8
Behaviour-driven	9	10	11	12

Very plausible	Plausible	Depends	Questionable	Implausible
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4 Pathway choice and current debate on the European climate policy

The pathway choice is related to current debate on the future of European climate policy. In January 2014 the European Commission presented the 2030 policy framework on climate and energy, which aims to make the EU's economy and energy system more competitive, secure and sustainable (European Commission, 2014). The EC proposes to set a new reduction target for domestic GHG emissions of 40% in 2030 compared to emissions in 1990. In relation to renewable energy, the EC proposes a share of renewable energy in the EU of at least 27%. The proposal for an energy saving target will be analysed in a review of the Energy Efficiency Directive in late 2014.

The 2030 policy framework proposed by the EC establishes that the EU ETS should remain the central instrument of the EU's policy to combat climate change. The EC acknowledges that the EU ETS has failed to encourage investment in low-carbon technologies and, therefore, a reform of the system is necessary. The EC proposal does not consider the expansion of the EU ETS to cover other sectors. The main objective of the reform is to make the EU ETS effective in the promotion of low-carbon technologies. The EC proposes to establish a market stability reserve, which would adjust the supply of allowances based on a pre-defined set of rules. The reform would stabilize allowance prices and, thus, improve resilience to market shocks and enhance market stability. This new structure would imply a shift from the volume approach to the price approach, and it would have similarities to a carbon tax. Indeed, a carbon tax is



the preferred choice of many authors (e.g. Goulder and Schein, 2013). Like a cap and trade scheme, a carbon tax is a market-based instrument which could be implemented across the EU. Although both policy instruments are equivalent in many dimensions, a carbon tax may reduce carbon price volatility and avoid policy errors and problematic interactions with other climate policies in the face of uncertainties.

Another important debate on the future of European climate policy is the number of targets to be pursued, which is somehow related to the policy pathways presented in the previous section. A scenario with a single reduction target would fit better with a market driven pathway, while a scenario with two or more targets could fit in both a market driven pathway and a technology-specific pathway. The behavioural-driven pathway might be a choice in absence of binding targets.

The advocates of a single reduction target argue that GHG emissions is what matters and it is irrelevant how the emission target is met. A market-based instrument such as the EU ETS would achieve the emission target cost-effectively. The interaction of the EU ETS with other instruments such as technology-support policies is considered inefficient (Stavins, 2014). Therefore, the market driven pathway might be the best choice when there is a single reduction target.

On the other hand, both a market driven and a technology-specific pathway can fit in a scenario with different targets for emissions reduction, renewable energy and energy efficiency. The advocates of separate targets argue that targets are mutually supportive, remove market barriers, avoid lock-in and support innovation (Höhne, 2013). The achievement of different targets requires several instruments, which can be market-based instruments or technology support instruments. Currently the promotion of renewables and energy efficiency has been mainly based on the interaction of the EU ETS and technology support policies (e.g. feed-in tariff and energy efficiency standards). Nevertheless, in the future, they could be promoted only through market-based instruments and, therefore, a market driven pathway would be compatible with different targets. Indeed, the EC proposal states that “the benefits of renewable energy must be exploited in a way which is to the greatest extent possible market driven” and “subsidies for mature energy technologies, including those for renewables, should be phase out”.

The 2030 policy framework proposed by the EC establishes an emission target and a renewable energy target. However, in contrast to the 2020 framework, the renewable energy target would not be binding on the Member States. The EC argues that Member States need flexibility to meet their emission targets and, therefore, energy efficiency and renewable energy targets should not be binding at national level. The proposal also states the need to promote further integration and competition in the energy market. This would require a new governance framework and, as argued above, governance is critical for policy pathways. The EC proposes a governance structure where Member States elaborate their plans and the EU coordinates and assesses those plans to ensure compliance with climate and energy objectives. In absence of binding national targets, the new governance should generate new

ways to harmonise national policies. Given that the new governance still has to be specified, it is difficult to assess the political pathway that could fit.

5 Evaluation of the different pathways

In this section, we explore the strengths and weaknesses of each climate policy pathway in terms of different aspects of ‘optimality’, to detect the existing trade-offs between them. Following previous documents of the CECILIA2050 project, the assessment of each scenario covers three dimensions: environmental effectiveness, cost-effectiveness and feasibility². The environmental effectiveness criterion assesses whether the instrument mix is able to bring about the necessary emission reductions. The cost-effectiveness criterion measures the cost associated with the emission reduction. This criterion includes the capacity to reduce emissions at least cost now (static efficiency) and over time (dynamic efficiency). The latter refers to the instrument mix potential to lower abatement costs in the future. The feasibility criterion measures the risk that the policy fails to be adopted as planned and/or to deliver as expected.

5.1 Environmental effectiveness

As mentioned above, all pathways are potentially able to meet the emission target. However, not all instrument packages have the same probability of meeting the target. The empirical evidence shows that some instruments are more effective in reducing emissions. Thus, in this section, we discuss the likelihood that the emission target would be met in each pathway.

Market-based pathway: in general, the environmental effectiveness of market-based instruments is high. In the presence of efficient markets and rational consumers, high carbon price signals lead to significant emission reductions. The key instrument in the market-based pathway is the EU ETS. The emission reduction of those sectors covered by the EU ETS is mainly determined by the emission cap. Setting a cap ensures that emission limits are not exceeded, which implies that it is very likely that the emission target is met. Therefore the environmental effectiveness would be determined by the level of the cap.

The EU ETS ensures a certain emission reduction but not a carbon price level. When overlapping instruments are implemented, they introduce an element of uncertainty because their success cannot be predicted. The overachievement on their targets does not result in lower emissions, but in a lower EU ETS price.

In those sectors not covered by the EU ETS, direct or indirect carbon taxes are the main drivers of emissions reduction. In contrast to the EU ETS, taxes do not ensure a certain emission reduction. Moreover, in presence of market failures (e.g. principal-agent problem,

² Task 1.1 of CECILIA2050 (“Defining the concept of optimality, including political and legal framework conditions”) develops the criteria to assess policy instrument mixes.

capital market imperfections) and irrational consumers, price signals may not lead to the expected emission reduction. IPCC (2014) points out that, in the short-run, consumers' response to indirect carbon taxes such as energy taxes is small; however, the long-run effects of energy taxes can be large. Although this pathway foresees a gradual removal of overlapping instruments, the environmental effectiveness of taxes could be enhanced with information measures and financial subsidies to overcome market barriers.

Technology-specific pathway: regulatory approaches are effective in improving energy efficiency and in reducing carbon intensity. When price premiums are high enough, feed-in tariff schemes have proved to be effective in the promotion of renewables. Efficiency standards are also effective in reducing energy intensity in the transport and building sector. Moreover, in presence of market failures, their effectiveness in reducing emissions can be higher than market-based instruments.

However, energy efficiency gains might not lead to proportional energy reductions. Rebound effects may reduce the environmental effectiveness of efficiency standards. Energy efficiency can lead to lower costs of supply and hence lower energy prices, resulting in price and income effects. This causes some increase in energy demand again.

In this pathway, the rebound effect is a key factor on the environmental effectiveness of the instrument package. Although the main drivers of the emission reduction are technology-support instruments, the EU ETS and energy taxes remain, mainly because the carbon price signal is important to moderate rebound effects.

Behaviour-driven pathway: the environmental effectiveness of this pathway is very uncertain. IPCC (2014) states that it is not possible to draw a final conclusion about the effectiveness of information measures from the empirical evidence. So far, information measures have been implemented to overcome market failures and, therefore, their role has been supplementary to other instruments. It is thus difficult to estimate the effectiveness of information measures, particularly when they are the main drivers of the emission reduction. The effects of information measures on public awareness and, thus, on behavioural change have not been analysed sufficiently.

5.2 Cost effectiveness

Market-based pathway: static cost-effectiveness is the main strength of this scenario. Removing those instruments that interact with the EU ETS, the price signal would be unique across sectors and countries. A unique carbon price allows companies to cut their emissions in the most cost-effective way. However static efficiency may be reduced by market failures. In the electricity sector, for instance, the price signal may not be sufficient to promote energy efficiency measures, whose abatement cost is below the carbon price of the EU ETS (the 'failure' here being a tax that is below the marginal damage cost). Another example would be capital market barriers that prevent households from purchasing low carbon appliances. Similarly, irrational households may not internalise the savings of more efficient appliances.

In those sectors not covered by the EU ETS, a direct or indirect carbon tax may be set. The overall efficiency of this scenario will depend on whether carbon taxes are set in line with the carbon price of the EU ETS (the greater the difference between the two the greater will be the cost inefficiency in achieving a given target reduction). The static efficiency of carbon taxes can also be reduced by market failures, such as the ones described above.

If static efficiency is the main strength of this pathway, dynamic efficiency is one of the main weaknesses. Despite the structural reform of the EU ETS, the carbon price signal may not be sufficient to encourage innovation and, thus, reduce abatement costs in the future. The high volatility, which has characterized the EU ETS carbon price in the first trading periods, may hamper innovation in low carbon technologies. The public support for basic R&D may not be sufficient to encourage innovation.

Technology-specific pathway: the static efficiency of technology-support instruments is often considered lower than that of market-based instruments. This is based on the assumption that governments have less information than markets. Therefore, they will not always choose the cheapest ways to reduce emissions. As mentioned above, however, this is not always true. Market failures may impede households from implementing cost-effective measures and regulatory measures can help to overcome these failures. However, in contrast to economy-wide carbon pricing, this scenario will not lead to equalisation of the marginal abatement cost across sectors and countries. Regulatory instruments may promote the wrong technology, increasing the burden on companies and/or households.

The dynamic efficiency of this pathway could be high. In general, regulatory measures provide a good framework which incentivises private innovation in low-carbon technologies (as long as they themselves are seen as stable). Moreover, this scenario foresees the active role of government in promoting specific technologies. Public funding may be beneficial for innovation.

Behaviour-driven pathway: the static efficiency of this pathway should be high. Regardless of price signals, higher public awareness incentivises behavioural change. The absence of high carbon prices does not imply that companies and households always act ineffectively to reduce emissions. They could still look for cheap ways of reducing emissions, given information and educational measures that help to identify efficient measures.

The demand for clean technology comes from the public awareness about climate change. In the absence of a high carbon price, this may not be enough to provide a stable framework for private R&D and innovation. This scenario foresees public funding for innovation in low carbon technologies which should enhance dynamic efficiency.

5.3 Feasibility

Market-based pathway: when emission reduction is driven by carbon price signals, these have to be high enough to have an effect on emissions. Too high carbon prices may affect the feasibility of this scenario. As argued by IPCC (2014), despite the attractive properties of

market-based instruments, their feasibility is low, because the cost of the emission reduction is more transparent than other climate policies. There is a trade-off between feasibility and environmental effectiveness. The 2050 target requires a more ambitious cap for the EU ETS, which will face opposition from companies that are most affected.

The expansion of the EU ETS could be beneficial for the feasibility of this pathway. IPCC (2014) states that emission trading schemes find less opposition from industry than taxes. Moreover, given that this scenario assumes some international agreement, the EU ETS could be linked to other schemes, thereby increasing its efficiency.

The distributional effects can reduce the feasibility of this pathway. The EU ETS has been criticized because of the additional profits earned by some companies to which allowances were allocated for free. This was important to get support from big utilities; however consumers faced higher energy prices and bore the majority of costs. The distributional effect of energy taxes is not obvious. Fuel taxes, for instance, are generally progressive in poor countries, while they are neutral or weakly regressive in rich countries (IPCC, 2014). The way in which tax revenues are recycled could be important to increase its feasibility. Regardless of the distributional effects, fuel taxes face the opposition of influential groups.

Technology-specific pathway: although regulatory measures are generally more costly, they face less resistance by households. In contrast to carbon prices, the cost of the emission reduction is less transparent in this scenario. In general, emission standards for appliances or vehicles are not identified with higher costs. Besides, this pathway foresees the implementation of subsidies to purchase low-carbon technology. Subsidies are well accepted by the general public, probably because they are not completely identified with direct higher outlays (the fact that they have to be paid for through taxes gets somewhat lost).

On the other hand, industry is more likely to oppose to this instrument mix. Industry is aware of the costs generated by regulatory measures. They may prefer market-based instruments, which give the flexibility to cut their emissions in the most-effective way.

This scenario assumes a strong participation of the public sector. Public subsidies, for instance, are used to promote clean technologies. The feasibility of this scenario would depend on the availability of public funding. Increasing public debts in several Member States may reduce the feasibility of this scenario.

Behaviour-driven pathway: this pathway encourages companies and households to take their own actions to reduce emissions. Based on information and education campaigns, the instrument mix improves consumer awareness about climate change. In the absence of high price signals and mandatory regulations, the instrument mix would be widely accepted by the general public. Voluntary approaches are generally preferred to mandatory rules.

‘Free-riding’ is a serious risk in this pathway. Voluntary actions to reduce emissions imply private costs, but public benefits. Some consumers and/or firms, however, may not reduce their emissions and benefit from lower emissions. If the emissions reduction burden is not evenly distributed, the feasibility is reduced.

Table 7. Trade-off among climate policy instrument scenarios

	Market	Technology	Behavioural
Environmental Effectiveness	Medium	High (**)	Low
Static efficiency	High	Medium	Medium
Dynamic efficiency	Medium (*)	High	Low
Feasibility	Low	Medium	High

(*) Depends on the long term stability of the instrument

(**) Subject to the rebound effect not being strong

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