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THE IMPACTS OF INTRODUCING A CO_2 FLOOR PRICE IN THE ELECTRICITY SECTOR

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Pending a deeper reform of the European CO_2 allowances trading scheme (EU ETS), the French government plans to introduce a floor price in 2017 of about €30/tCO_2 on electricity sector emissions. Taken unilaterally by France, this measure could be extended to partners who support the approach.

Conducted on the basis of the ZEPHYR-Elec and ZEPHYR-EU ETS models, simulating short-term equilibria in the electricity and CO_2 allowance markets, this study aims to assess the impacts of such a €30/tCO_2 floor price, applying from 2017.

With the unilateral introduction of this floor price in France, the price of electricity in the wholesale market would increase by €2.6 to €3.4/MWh. The use of French power plants would be reduced in favour of foreign plants, since the option of replacing coal by gas in the domestic supply is limited. It would result in a decrease in national emissions of 3.5 to 9.7 MtCO_2. With an unchanged CO_2 allowances cap in the European system, the decline in emissions from the French electricity system would cause a slight weakening in the allowance price and increased emissions from actors not affected by the floor price, thus nullifying the intended environmental benefit.

In the event of introducing a European floor price, the price of electricity on the wholesale market would increase by €12/MWh. French thermal power generation, having become more competitive, would increase slightly, limiting the reduction in the country's emissions. At a European level, the fall in emissions could amount to 124 Mt per year, which would bring down the allowance price to zero. The market system would become a pseudo-tax device generating a net environmental benefit of about 50 Mt less CO_2 per year over the period 2017-2020.

In both cases, for a floor price applied to the electric sector to bring the intended environmental benefits, its introduction would need to be accompanied either by in-depth reforms of the European carbon pricing mechanism, or by the introduction of dynamic management of the supply of CO_2 allowances, or by switching to a taxation system.

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SUMMARY

We aim to measure the impact of a tax mechanism introducing a floor price of €30/tCO_2 for electricity sector emissions. The analysis is conducted using the ZEPHYR-Elec and ZEPHYR-EU ETS models, representing the short-term equilibrium of the electricity and the CO_2 allowances markets respectively. The impacts are measured in terms of deviation from a baseline.

✓ **The case of a unilateral floor price for CO_2 allowances**

The introduction of a €30/tCO_2 floor price raises the cost of domestic thermal power generation and leads to, at unchanged demand, a fall in production in favour of imports. It results in:

- An increase of €2.6 to €3.4 in the price per MWh in the wholesale market as an annual average, reflecting the increase in the marginal cost of electricity supplied;
- A reduction in domestic emissions of 3.5 to 10 MtCO_2 on the basis of assumptions regarding the relative prices of coal and gas, and an increase in import-related emissions of 3.7 to 6.2 MtCO_2;
- Limited substitution from domestic coal-fired to gas power plants due to cross-border trade. From this perspective, statutory decommissioning of coal-fired plants would result in reduced loss in domestic production and a smaller increase in electricity prices.

Range of impacts of a French unilateral floor price in the electricity sector		
Domestic electricity generation		-9.3 / -14.5 TWh
	Coal	-7.3 / 0 TWh
	Gas CCGT	-9.3 / -13.1 TWh
Electricity imports		+9.3 / +14.5 TWh
Total emissions		-3.7 / +0.2 MtCO_2
	Domestic	-3.5 / -9.7 MtCO_2
	Imported	+3.7 / +6.2 MtCO_2
Average price of electricity		+€2.6 / +€3.4 /MWh

The impact of the measure on the equilibrium of the EU ETS over the 2017-2020 period would be small because of the limited weight of French electricity sector emissions:

- The equilibrium price of the CO_2 allowances falls by €0.7/tCO_2 in the first year and €0.2 in the fourth;
- The allowances surrendered by the electricity sector lead to a rise in non-electricity sector emissions that cancels out the intended environmental benefit;
- Auction proceeds returning to France decrease by a cumulative €77 million from 2017 to 2020 and taxation yields €1,615 million over the same period.

✓ **The case of a European floor price for CO_2 allowances**

The introduction of a European floor price of €30/tCO_2 improves the competitiveness of the French low-carbon electricity sector, which reduces imports to the benefit of production. It results in:

- An €11.6 increase in the price per MWh due to higher costs for all thermal power generation;
- Little change in domestic emissions (with increased use of gas power plants and small decline in coal-fired plants) and a decline in import-related emissions;
- A slight decline in the use of coal-fired plants because power generated from foreign gas is less competitive than in the case of a unilateral price floor.

If the European cap on allowances remains unchanged, the market mechanism is transformed into a pseudo-tax that burdens electricity production:

- The European electricity sector reduces its emissions by 124 MtCO_2 a year between 2017 and 2020. Surrendered allowances are only marginally absorbed by the Market Stability Reserve (30 MtCO_2 per year) and the price drops to zero. The industrial sector returns to its counterfactual situation (without a CO_2 price);
- The proceeds of auctions allocated to France disappear, but taxation brings in €705m a year;
- Unlike the previous case, this pseudo-tax system generates an environmental benefit, in the form of a net reduction of 50 MtCO_2 a year in CO_2 emissions in Europe between 2017 and 2020.

✓ **Lessons from the CO_2 pricing models**

The introduction of an allowances floor price for the electricity sector does not spontaneously lead to a strengthening of the carbon price signal in Europe. For this to happen there would need to be radical reform in the governance of the European CO_2 allowances market or a switch to a tax system:

- For the unilateral floor price to generate an environmental benefit, the allowances cap would need to be lowered by the amount of the electricity sector's reduction of emissions. Such a reduction is impossible under current rules. It would be feasible if the authority responsible for managing the market were given the mandate to adjust the allowances cap in response to measures taken unilaterally by Member States. Such dynamic control of the supply of allowances is the key to any reform of this market;
- To perpetuate the environmental benefit generated by a European floor price, it would be necessary to change the market system into a tax on electricity sector emissions. Such a transformation would bring simplicity and predictability, but faces major institutional constraints. Nevertheless it goes back to a basic economic truth: the most appropriate way to ensure predictability of a price signal is through taxation rather than the market.

In both cases, the question arises of how to include the industry in this new pricing system or in a possible ad hoc arrangement, other than agreeing to a return for this sector to the free CO_2 emissions prevailing before 2005.

THE INTRODUCTION OF A CO_2 FLOOR PRICE IN THE ELECTRICITY SECTOR: IMPACT STUDY

In a study published in November 2015, the Climate Economics Chair conducted an assessment of the impacts that may result from the introduction of a floor price applicable to CO_2 emissions from the electricity sector alone. It had then not been possible to quantify the effects of the measure on cross-border electricity trading. This paper presents new assessments that incorporate this cross-border trading.

In the first section, the paper recalls the two issues raised by the introduction of a floor price on emissions in the electricity sector and presents the method used to assess impacts. We then proceed to a detailed assessment of the impact of the measure on the French electricity sector. In the third step, we analyse its potential impact on the functioning of the European CO_2 emissions trading system. Finally, we consider what lessons can be drawn from this modelling exercise.

1. THE ECONOMIC MECHANISMS AT WORK

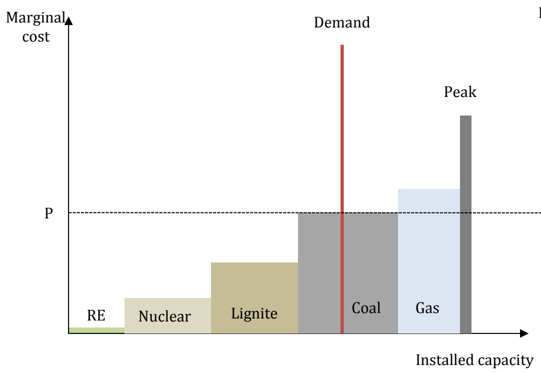
The introduction of a CO_2 floor price applicable to electricity sector emissions changes the relative costs of different production technologies, leading to a new equilibrium in the electricity market. In this new equilibrium, the use of the most CO_2-emitting technologies is reduced, which through a feedback effect changes the equilibrium conditions between supply and demand in the CO_2 allowances market.

1.1 Linkages in the electricity market

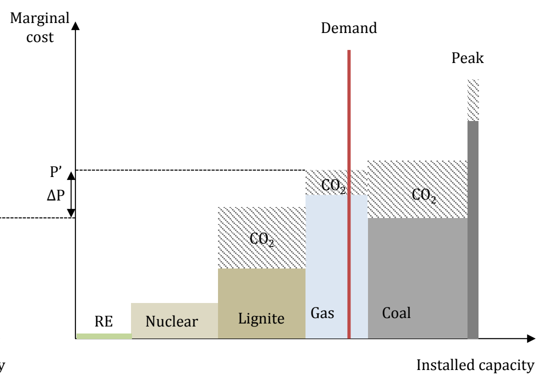
The short-term equilibrium of the electricity market has to constantly adjust available production resources to demand, which fluctuates depending on the time of day and the season. For a given level of demand, these resources are ranked according to their increasing variable cost. Equilibrium is reached at a price that equals the cost of the last plant called on. The introduction of a floor price changes the order in which the power plants are called on, as the following graph shows.

Figure 1 – Carbon floor price in the electricity market: the economic mechanism

Merit order without a floor price



Merit order with a floor pricer



Source: Climate Economics Chair

The introduction of a CO_2 floor price increases the variable cost of the most carbon-emitting plants. It may cause a change in the order in which plants are called on.

In the short term, the variable production costs of CO_2-emitting technologies are raised by the floor price, which changes the order of calling on different plants, depending on their emission factors. This results in a new equilibrium in the electricity market:

- The price of electricity offered by the domestic system is augmented by higher costs of CO_2-emitting technologies and the changing order of calling on plants as a result. The magnitude of this price effect depends on domestic and imported capacity constraints, that vary according to daily and seasonal load curves;

- If the floor price applies only in France, the price differential between domestic electricity and that of its European partners results in an increase in net electricity imports. The extent of the adjustment depends on the constraints on the interconnections with and availability of production capacities abroad at the time they are called on;

- If the floor price applies across Europe, French electricity prices increase less than in other countries. Production increases due to the growth of net exports, which offsets the decline in domestic emissions. The rise in electricity prices is considerably greater, because of the simultaneous higher costs of domestic and foreign production.

To understand these linkages, we use the ZEPHYR-Elec model, specifically developed to represent the constraints of interconnection with foreign markets. Initially, the model is calibrated on 2015 and retroactively reproduces the equilibrium of the electricity market. It then simulates the incorporation of a €30/t CO_2 floor price, taking into account the linkages described above, but without including the feedback effect on electricity demand, a justified assumption in the short term. Lastly, the model calculates for each equilibrium of the electricity market the reduction in the volume of CO_2 produced by the sector as a result of the floor price. The method can thus quantify the impacts of the measure through the deviation from the 2015 baseline.

1.2 Linkages in the CO_2 allowances market

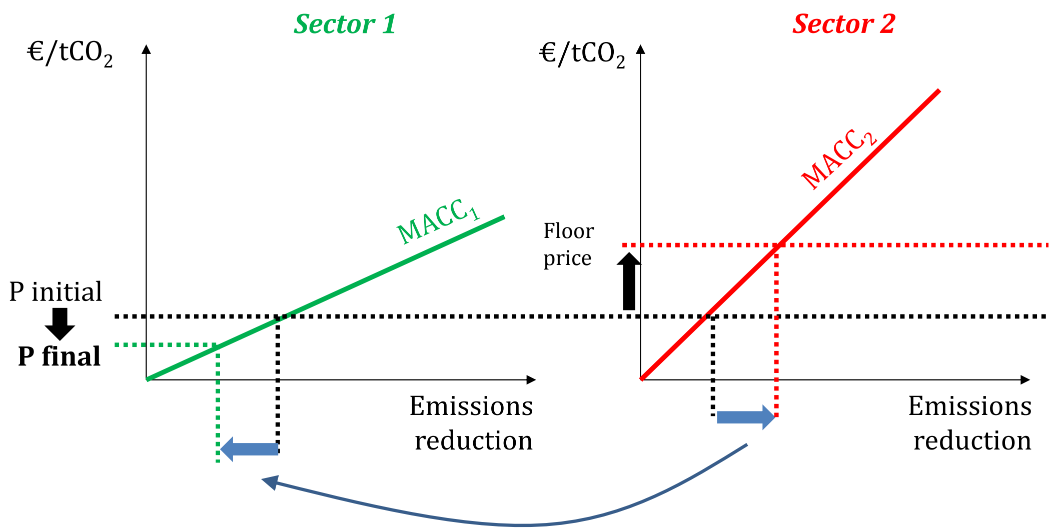
Equilibrium of the CO_2 allowances market is formed by combining the supply of allowances set ex ante by the public authority (the emissions cap) and demand determined by the need for compliance of installations in surrendering allowances equal to the volume of their CO_2 emissions. Demand includes an anticipation parameter, since installations can retain their unused allowances for future compliance. The CO_2 allowance equilibrium price secures a return on all emission reductions whose unit cost is less than the allowance price. These reductions can be arranged in order of increasing cost and represented by a curve plotting the reduced amounts of emissions as the price of CO_2 rises (the marginal abatement cost curve).

The introduction of a floor price in the electricity sector encourages the installations concerned to reduce their emissions at costs higher than the equilibrium price of CO_2 allowances. With an unchanged overall cap, electricity producers surrender allowances, which are then put on the market. There is therefore a transfer of emission rights to installations not subject to the floor price, allowing these installations to increase their emissions (see Figure 2). This process can result in two types of situation:

- If the quantity of quotas surrendered by the electricity sector subject to the floor price is not absorbed by the plants concerned, the allowances market establishes a new equilibrium, at a lower CO_2 market price and with simply a transfer of emissions within the cap;

- If demand by installations not covered by the floor price is insufficient to absorb the quotas surrendered, the CO_2 allowances market price falls to zero and the market system becomes de facto a pseudo-tax system imposed on electricity generation. In this case, there is an environmental benefit because the reduction in emissions induced by the floor price is higher than the increase in emissions from actors not affected by the measure.

Figure 2 – Unilateral floor price in an allowances market: the economic mechanism



Source: Climate Economics Chair

The floor price triggers further reductions in Sector 2, which surrenders the available allowances to Sector 1. The fall in the allowance market price depends on the respective slopes of the abatement curves (MACC). If the allowance price falls to zero, Sector 1 returns to its counterfactual situation and the CO_2 allowance market no longer provides any economic signals.

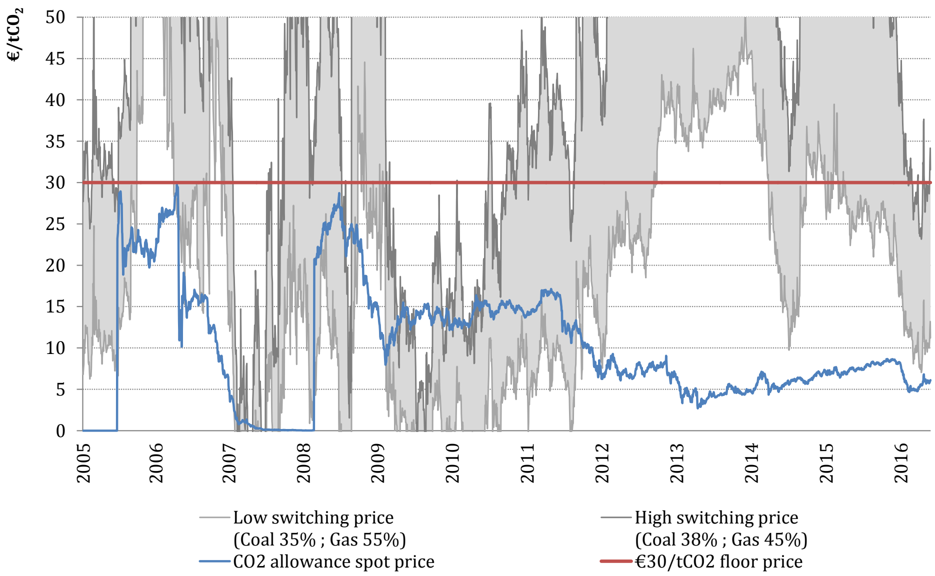
To analyse these linkages, we use the ZEPHYR-EU ETS model, which represents the dynamics of the European CO_2 allowances system. For each year the model calculates the allowance price that ensures a balance between the supply of and demand for allowances, assuming that all achievable abatements below the market price are made. The surplus balance is carried over from one year to the next ("banking"). A baseline scenario incorporating the EU rules already adopted at the European level, in particular the delay in the auction period ("backloading") and the introduction of a stability reserve, is calculated up to 2020. The introduction of a floor price in 2017 is then simulated, holding the allowance price at €30 for the installations concerned. The model calculates any new market equilibria that it can find. The impact of the floor price is thus measured by deviation from the baseline scenario over the period 2017-2020.

2. IMPACTS ON THE FUNCTIONING OF THE ELECTRICITY INDUSTRY

2.1 Initial observation: too low a CO_2 price to trigger the substitution of gas for coal

In the short term, the introduction of a CO_2 price can greatly reduce emissions in the electricity sector when it sufficiently augments the variable cost of production from coal, which is more carbon-emitting than production from gas. Replacing coal by gas becomes economically viable at a CO_2 price level, termed the "switching price", dependent on three factors: the price of coal, the price of gas and the respective thermal efficiencies of coal and gas plants. The graph below shows that this level has fluctuated since the launch of the EU-ETS, due to respective changes in gas and coal prices. Since late 2011, the price of CO_2 allowances on allowances market has remained below the switching price, a situation that has led to increased use of sometimes older, coal-fired plants at the expense of more recent and less carbon-emitting gas plants.

Figure 3 – CO_2 allowance price triggering the substitution of gas for coal



Source: Climate Economics Chair, from ICE Futures and Bluenext data

Since late 2011, the allowance price on the European market has been too low to trigger the substitution of gas for coal. A price of €30/t would have triggered substitution only for part of that period, due to the sharp fall in coal prices compared to gas in 2012 and 2013.

2.2 From potential substitution to real substitution: the model used

For substitution actually to occur, a further condition must be met: the least emitting production facilities that have become potentially viable must be available to meet demand. But the availability of these resources varies greatly in the short term, especially in relation to the time of day and the season. In addition, the domestic electricity market is linked to foreign markets through interconnections that may be either available or saturated.

In its current configuration, the ZEPHYR-Elec model represents electricity transmission for eleven production technologies and calculates on an hourly basis the merit order of these technologies minimizing the cost of production and the electricity price ensuring equilibrium between supply and demand. The model was calibrated on 2015, based on data released by the French transmission operator RTE, and allows us to find ex-post the main components of the domestic electricity balance sheet.

A specific feature was added to address cross-border trade. Imports are represented by two “borders” through which electricity generated from coal (mainly imported from Germany) and from natural gas (mainly imported from Italy) is imported. These two “borders” were calibrated on the basis of RTE 2015 balance sheet data and play a part in supply-demand equilibrium by replacing domestic production resources. Conversely, an export border is introduced, with the assumption that only nuclear-generated electricity is exported in the baseload period.

To assess the impact of introducing a CO_2 allowance floor price, we start from this equilibrium represented ex-post in the model, then introduce a CO_2 floor price of €30/tCO_2. The model recalculates 8,760 hourly equilibria, enabling it to optimize the supply of electricity given the new variable costs of domestic and imported thermal resources and the new electricity prices resulting from them. It thus represents the electricity market equilibrium that would have occurred with a minimum price of €30/tCO_2. This method thus makes it possible to assess the impact of the measure through deviation from the 2015 base year.

2.3 Impacts of a €30/tCO_2 floor price introduced at a national level

The introduction of a CO_2 allowance floor price reduces the price competitiveness of French production facilities and increases imports. The decrease in production is about two-thirds for coal-fired plants. For gas plants the decrease is slightly higher, because French coal plants remain globally more competitive given the relative prices.

Figure 4 – Impacts of a unilateral French floor price of €30/tCO_2

	Baseline scenario	Floor price France	Absolute variation	Relative variation
Domestic electricity generation	533.6 TWh	519.1 TWh	-14.5 TWh	-2.7 %
Coal	8.6 TWh	3 TWh	-5.6 TWh	-65.5 %
Gas CCGT	12 TWh	3.1 TWh	-8.9 TWh	-74.2 %
Electricity imports	29.6 TWh	44.1 TWh	+14.5 TWh	+49 %
Total emissions	36.3 MtCO_2	33.5 MtCO_2	-2.8 MtCO_2	-7.8 %
Domestic	13.4 MtCO_2	4.8 MtCO_2	-8.7 MtCO_2	-65.5 %
Imported	22.9 MtCO_2	28.7 MtCO_2	+5.8 MtCO_2	+25.4 %
Average price of electricity	€33.2/MWh	€36.4/MWh	€+3.2/MWh	+9.7 %
CO_2 price and energy price assumptions				
Average CO_2 price France	€8/tCO_2	€30/tCO_2	–	–
Average CO_2 price EU	€8/tCO_{22}	€8/tCO_2	–	–
Average coal price	€51/t	€51/t	–	–
Average natural gas price	€20/MWhp	€20/MWhp	–	–

Source: Climate Economics Chair

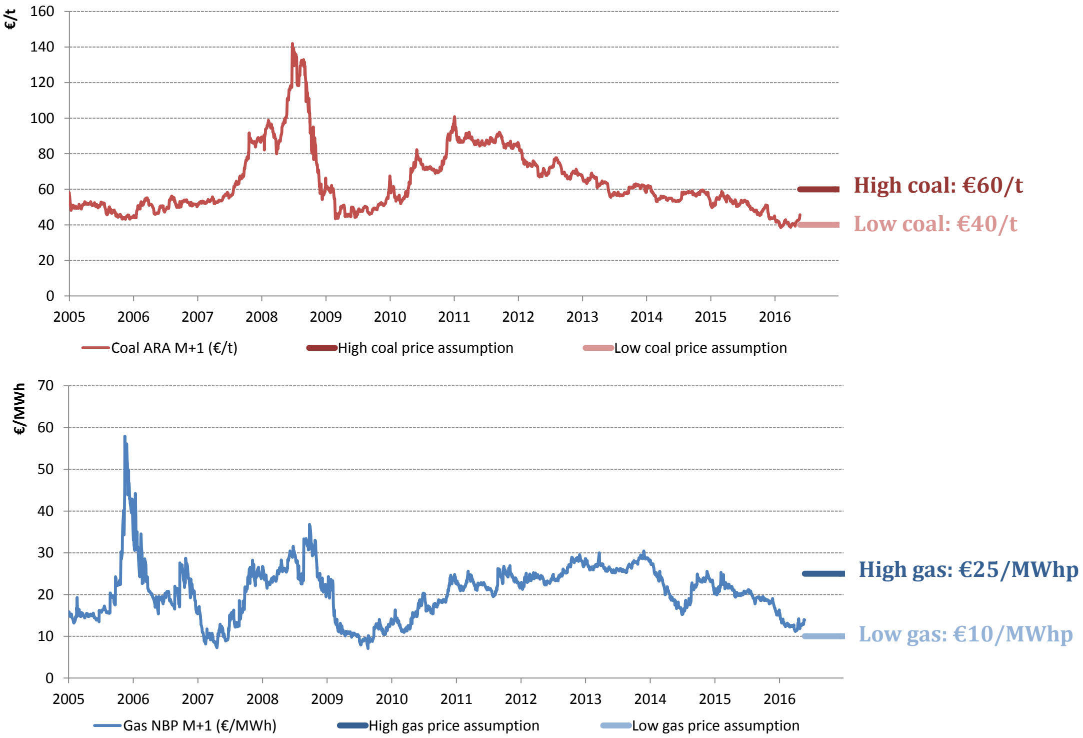
This results in lower CO_2 emissions from the domestic electricity sector of some 8.7 Mt CO_2 and an increase in import-related emissions of 5.8 Mt CO_2. Direct and indirect emissions from the power sector are thus only reduced by 2.8 Mt CO_2. As the sensitivity analysis shows, to further reduce emissions in the domestic sector, it is necessary, within the framework of our model, either to raise the price of CO_2 higher or to assume that the price of gas falls compared to coal.

The impact of the measure on the wholesale price of electricity arises from the higher costs of marginal thermal power plants and from substitution effects on the marginal plants called on resulting from change in the merit order. In our model this amounts to €3.2/MWh, or an increase of around 10% relative to the baseline price.

2.4 Sensitivity analyses

The above analysis was carried out on the basis of deviation from the 2015 baseline. To use it to forecast the impact of a floor price in 2017, certain precautions are called for. Among the many parameters liable to change the results, the most important concerns the evolution of relative prices. In fact results are very sensitive to changes in the prices of coal and gas and in terms of the floor price introduced.

Figure 5 – Observed prices of coal and gas in Europe, and selected scenarios



Source: Climate Economics Chair, from ICE Futures data

Since 2005, gas market prices in Europe have seen bullish and bearish periods. Coal prices have been less volatile in recent years, but there has been on a downward trend since late 2010. Changes in the relative price between the two fuels are particularly difficult to predict.

To shed light on future decision-making, we test the sensitivity of results on the 2015 baseline for three scenarios of changes in the relative prices of coal and gas:

- Scenario 1. Fuel prices stabilize at their average observed over the first five months of 2016. In this new environment, the CO_2 floor price triggers greater substitution from coal plants to gas plants. Domestic emissions fall by 9.7 Mt. The electricity price per MWh increases by only €2.6;

- Scenario 2. The price of gas rises to €25/MWh while the coal remains at the €40/t floor. In this scenario, the decline in production is lower following the introduction of the CO_2 price floor because French coal plants remain competitive relative to foreign gas. Emissions fall to a lesser extent and the electricity price per MWh rises to €3.4;

- Scenario 3. The price of gas stabilizes at the €10/MWh floor, while coal rises to the €60/t level. In this scenario, the price of the two fuels results in the substitution of gas for coal before the introduction of the CO_2 price floor. The introduction of a floor price now simply causes a substitution of French gas plants by foreign plants, and the increase in the electricity price per MWh is only €2.6.

The detailed results of the sensitivity analysis are given in the appendix. The approach can provide ranges that straddle the results obtained in the initial analysis. More than the central values, it is these ranges (Figure 6) that can be used to guide decision-making.

Figure 6 – Range of impacts of a unilateral French floor price of €30/tCO_2

		Range of impacts
Domestic electricity generation		-9.3 / -14.5 TWh
	Coal	-7.3 / 0 TWh
	Gas CCGT	-9.3 / -13.1 TWh
Electricity imports		+9.3 / +14.5 TWh
Total emissions		-3.7 / +0.2 MtCO_2
	Domestic	-3.5 / -9.7 MtCO_2
	Imported	+3.7 / +6.2 MtCO_2
Average price of electricity		+€2.6 / +€3.4 /MWh

Source: Chaire Economie du Climat

A second sensitivity analysis was conducted in terms of the floor price (Appendix 3). It reveals that at €20/t, the impact of the measure on domestic emissions is very low. Conversely, the introduction of a €56/t floor price leads to results comparable to those of the scenario of raising the price of coal relative to gas in terms of the replacement of coal plants by gas plants, but with a more significant impact on the price per MWh of electricity, which increases by 5.9 €.

2.5 The impact of introducing a European floor price of €30/tCO_2

Compared to the baseline situation, the introduction of a Europe-wide floor price for CO_2 allowances increases the price competitiveness French domestic production facilities relative to those of its more CO_2-emitting European partners. Domestic production increases slightly due to the 14% increase in the utilization rate of gas plants and a slight decline in the utilization of coal plants.

Total CO_2 emissions from domestic production increase marginally due to the mobilization of gas power plants, but the decline in imports results in a 2.6 Mt reduction in indirect emissions. In total, emissions related to the new equilibrium in the electricity market decrease by 2.3 Mt, while those in the electricity sector across Europe fell by more than 100 Mt.

In this scenario, the price of electricity increases more significantly because there is a simultaneous rise in variable production costs associated with domestic and foreign production facilities.

Figure 7 – Impacts of €30/tCO_2 EU floor price

	Baseline scenarion	Price Floor EU	Absolute variation	Relative variation
Domestic electricity generation	533.6 TWh	534.5 TWh	+0.8 TWh	+0.2 %
Coal	8.6 TWh	7.6 TWh	-1 TWh	-11.2 %
Gas CCGT	12 TWh	13.8 TWh	+1.8 TWh	+14.9 %
Electricity imports	29.6 TWh	28.8 TWh	-0.8 TWh	-2.7 %
Total emissions	36.3 MtCO_2	35.1 MtCO_2	-1.2 MtCO_2	-0.1 %
Domestic	13.4 MtCO_2	13.2 MtCO_2	-0.2 MtCO_2	-1.6 %
Imported	22.9 MtCO_2	21.9 MtCO_2	-1 MtCO_2	-4.3 %
Average price of electricity	€33.2/MWh	€44.8/MWh	+€11.6/MWh	+34.9 %
CO_2 price and energy price assumptions				
Average CO_2 price	€8/tCO_2	€30/tCO_2	–	–
Average coal price	€51/t	€51/t	–	–
Average natural gas price	€20/MWhp	€20/MWhp	–	–

Source: Climate Economics Chair

3. IMPLICATIONS FOR THE FUNCTIONING OF EUROPEAN CO_2 EMISSIONS TRADING SCHEME

The assessment was conducted using the ZEPHYR-EU ETS model, which simulates the operation of the CO_2 allowances trading scheme in Europe. The baseline scenario describes the anticipated evolution of supply-demand equilibrium for allowances up to 2020 by incorporating the decisions already taken with regard to the auction schedule and the Market Stability Reserve (MSR). The model is then modified by the introduction in 2017 of an allowance floor price, in France and in Europe. The impacts are measured in terms of deviation from the baseline scenario, over the period 2017-2020.

3.1 Construction of the baseline scenario

The ZEPHYR-EU ETS model describes the supply-demand equilibrium of allowances over time, assuming that the installations covered implement all CO_2 emission reductions costing less than the allowance price. In each period, the model calculates the price that equates supply and demand for allowances, taking into account allowances set aside (banking) and carried over to the following period.

On the supply side, the baseline scenario incorporates the progressive reduction rules of the distributed allowances cap, the revised auction schedule up to 2020 (backloading) and the start of the MSR in 2019.

On the demand side, it is based on three sets of parameters:

- Standard assumptions in terms of economic growth and energy prices (OECD and IEA scenarios);
- Marginal abatement cost curves representing the emissions reduction options in the power sector and other industries for different CO_2 price levels;

- A parameter determining the volume of allowances that installations decide to retain (banking), depending to their expectations about the future constraint. This anticipation parameter has been calibrated to reproduce the historical evolution of the market.

The baseline scenario describes a slow decrease in the stock of allowances in circulation from 2016 to 2018 followed by a more marked decrease in 2019 and 2020 because of withdrawals by the Market Stability Reserve. The allowance price rises slowly between 2016 and 2018 (up to about €8/tCO_2) in response to the lower cap, then rises sharply in 2019 and 2020 to about €19/tCO_2 following the withdrawal of allowances by the MSR (approximately 230 Mt/year). In the baseline scenario, by the end of 2020 the MSR contains approximately 1,400 Mt (including 900 Mt from backloading).

3.2 Impacts of introducing a French national floor price

The introduction of a floor price in the French electricity sector encourages the installations concerned to reduce emissions costing more than the allowance equilibrium price. As a result, there is an additional 11 MtCO_2 decrease in CO_2 emissions from the European electricity sector between 2017 and 2020. The allowances surrendered re-enter the market, causing a decrease of €0.7 in the allowance price in the first year and €0.2 in the fourth year. This reduction generates a comparable increase in emissions from facilities not affected by the floor price, which cancels out the intended environmental benefit. The transfer is neutral for the MSR.

The decrease in the allowance price reduces the auction proceeds allocated to the French state by €77 million over the period. This decrease is largely offset by revenues of around €1,615 million from domestic taxes, which compensate for the difference between the market price of allowances and the target price floor.

Overall, the simulation shows the impacts on the EU ETS to be fairly marginal, due to low-carbon nature of the French electricity industry. It is quite another matter if the measure is implemented on a wider scale in Europe.

Figure 8 – Impact on the EU ETS of a French €30/tCO_2 floor price for the electricity sector

	Baseline scenario	Floor price France	Absolute variation	Relative variation
Allowance price 2017	€6.1/tCO_2	€5.4/tCO_2	-€0.7/tCO_2	-11.5%
Allowance price 2020	€19.5/tCO_2	€19.25/tCO_2	-€0.22/tCO2	-1.1%
Cumulative EU emissions 2017-2020	7 067 MtCO_2	7 067 MtCO_2	0 MtCO_2	0%
EU Electricity	3 636 MtCO_2	3 625 MtCO_2	-11 MtCO_2	-0.3%
EU Non-electricity	3 431 MtCO_2	3 442 MtCO_2	+11 MtCO_2	+0.3%
MSR stock in 2020	1 377 MtCO_2	1 377 MtCO_2	0 MtCO_2	0%
Proceeds from auctions France Cumulative 2017-2020	€2 117 M	€2 040 M	-€77 M	-3.6%
Proceeds from auctions EU Cumulative 2017-2020	€49 235 M	€47 439 M	-€1796 M	-3.6%
Proceeds from tax diff. France Cumulative 2017-2020		€1 615 M		

Source: Climate Economics Chair

3.3 Impacts of introducing a European floor price

The introduction of a €30/tCO_2 floor price at the European level generates additional emission reductions in the electricity sector of 495 MtCO_2 (124 MtCO_2/year) over the period 2017-2020. The allowances surrendered return to the market, causing a decrease in the allowance price, which encourages industrial installations to increase their emissions. Because of the volumes released, these companies return to the counterfactual situation (without a carbon price) and the price falls to zero.

Despite the introduction of the Market Stability Reserve, which increases the stock of allowances withdrawn from the market by 60 MtCO_2, the market can no longer function. It turns into a taxation mechanism for the electrical sector, shown by the disappearance of auction proceeds, which is more than offset by taxation revenue: €94 billion, or almost twice the revenue from the auctions anticipated in the baseline scenario.

Unlike the case of the French national floor price, whose introduction is neutral for European emissions, this pseudo-tax system generates additional emission reductions of 203 MtCO_2 over the period (51 MtCO_2/yr) in the European Union.

Figure 9 – Impact on the EU ETS of a European €30/tCO_2 floor price for the electricity sector

	Baseline scenario	Floor price EU	Absolute variation	Relative variation
Allowance price 2017	€6.1/tCO_2	€0/tCO_2	-€6.1/tCO_2	-100%
Allowance price 2020	€19.5/tCO_2	€0/tCO_2	-€19.5/tCO2	-100%
Cumulative EU emissions 2017-2020	7 067 MtCO_2	6 865 MtCO_2	-203 MtCO_2	-2,9%
EU Electricity	3 636 MtCO_2	3 141 MtCO_2	-495 MtCO_2	-13,6%
EU Non-electricity	3 431 MtCO_2	3 723 MtCO_2	+292 MtCO_2	+8,5%
MSR stock in 2020	1 377 MtCO_2	1 438 MtCO_2	+61 MtCO_2	+4,4%
Proceeds from auctions France Cumulative 2017-2020	€2 117 M	€0 M	-€2 117 M	-100%
Proceeds from auctions EU Cumulative 2017-2020	€49 235 M	€0 M	-€49 235 M	-100%
Proceeds from tax diff. France Cumulative 2017-2020		€2820 M		
Proceeds from tax diff. EU Cumulative 2017-2020		€94 234 M		

Source: Climate Economics Chair

In both cases, the impact calculations were made on the basis of unchanged expectations of market players. There is no doubt that these expectations will be modified in the event of introducing a European floor price. But they become particularly difficult to estimate because of the complexity and the growing instability of institutional rules to guide the decisions of actors operating in this market.

4. Lessons learned from the impact analysis

4.1 Usefulness of an additional ex-post evaluation

By construction, the impact analysis presented is based on simplifications, introduced for modelling purposes, that can only provide a stylised representation of reality. It is also based on various key assumptions, from which some impacts have been quantified through sensitivity analyses.

Among these assumptions, there is one of particular importance: the modelling assumes that the tax measure introduced instantly changes the price signal, by removing any uncertainty about the future price of CO_2 allowances. As a consequence, electricity companies fully integrate this factor into their short-term decisions. The only country to have experimented with such a mechanism is the United Kingdom, when it introduced the 2011 Finance Act, for application from 2013. Observation reveals that the tax measure adopted is not able in advance to specify the floor price, which can be only calculated ex-post.

The main recommendation is therefore to supplement the impact analyses carried out ex-ante by an ex-post evaluation of the UK experience, so as to draw relevant lessons from it.

4.2 Implications for the management of electricity sector: what instruments for what objective?

The justification for the introduction of a floor price is the indisputable inadequacy of the CO_2 allowance price to encourage switching from coal plants to generally newer and always less CO_2-emitting gas plants.

The impact study shows that the first substitutions resulting from the allowance floor price concerns gas power plants located abroad. For a substitution from coal to gas to occur domestically, there must be either a specific configuration of fuel prices or the introduction of a floor price higher than €30/tCO_2. This requirement leads on to the question of the match between the instrument used and the objective targeted.

- If the objective is to speed up the withdrawal, already begun, of French coal-fired plants, a regulatory measure could be considered. An additional simulation presented in the Appendix shows that the closing-down of French coal-fired plants leads to a new market equilibrium with reduced emissions, more domestic power generation from gas and an electricity price that increases less on the wholesale market than with the floor price;

- If the objective is the adoption of an allowance floor price at the European level, the measure leads to a very different electricity market equilibrium in the event of the objective being achieved. Domestic electricity production becomes more competitive in Europe, thereby boosting gas power plants and limiting production from coal-fired plants. In this context, CO_2 emissions from power generation on French territory do not fall and the price of electricity increases sharply.

In both cases, it is advisable to assess at the same time how the measure fits into the reform of the EU CO_2 emissions trading system.

4.3 Implications for the price of CO_2: reform the EU ETS or shift to taxation

The introduction of an allowance floor price in the electricity sector gives rise to linked effects that do not spontaneously strengthen the functioning of the EU ETS. To achieve the desired effects, it needs to be accompanied by changes in the CO_2 pricing system in Europe:

- The introduction of a unilateral floor price results in a transfer of allowances between sectors and a decline in the price of CO_2 allowances, but without any common environmental benefit. For it to result in an environmental return, the EU cap would need to be reduced by the amount of additional reductions made in response to the introduction of the floor price. Such a reduction is impossible in the current institutional framework. In this a scenario there is no coordination between a unilateral domestic (floor price) policy and the allowances trading system. As in the case of unilateral support for renewables, such lack of coordination undermines the effectiveness of the cap-and-trade system. One way to resolve the problem would be give an independent authority a mandate to adjust the allowance cap in response to measures taken unilaterally by Member States, or to allow Member States to proceed with the withdrawal of allowances;

- The introduction of a floor price at a European level would lead to a pseudo-tax mechanism on CO_2 emissions from power generation, providing a common environmental benefit proportional to the level of the tax. This transition to taxation is difficult to imagine in the current institutional framework, especially because of the unanimity rule required for any decision. Yet it takes us back to a standard economic lesson: the safest way to ensure predictability of the price signal is through a tax, not the market.

To achieve the intended results, the introduction of a floor price must therefore be accompanied by the establishment of dynamic management of the supply of allowances or a switch to a system of taxation on CO_2 emissions.

REFERENCES

Bonfils, H. and Laurencin, C. (2016). Another national carbon measure. A carbon price floor in France. IHS Energy insight, June 2016.

Bourbonnais, R. and Keppler, J. H. Estimation de l'elasticite prix de la demande électrique en France. CEEM Working paper 2013-6, Octobre 2013.

Commission de régulation de l'énergie (CRE). (2015). Le fonctionnement des marchés de gros de l'électricité, du CO_2 et du gaz naturel. Rapport 2014-2015, Novembre 2015.

Conseil économique pour le développement durable (CEDD). (2016). Instauration d'un prix-plancher du carbone pour le secteur électrique. Points de repères. Synthèse n°27, Juin 2016.

De Perthuis, C. and Trotignon, R. (2014). Governance of CO_2 markets: Lessons from the EU ETS, Energy Policy, volume 75, pp. 100-106, December 2014.

European Commission (2015). Report on the functioning of the European carbon market. COM(2015) 576 final, November 2015

Grosjean, G., Acworth, W., Flachsland, C. and Marschinski, R. (2014). After Monetary Policy, Climate Policy: Is Delegation the Key to EU ETS Reform? MCC Working paper 1/2014, May 2014.

Goulder, L. H. and Schein, A. R. (2013). Carbon taxes versus cap and trade: a critical review. Climate Change Economics, Volume 4, August 2013.

Goulder, L.H. (2013). Markets for Pollution Allowances: What Are the (New) Lessons? Journal of Economic Perspectives 27(1), Winter 2013.

Hansen, J-P. and Percebois, J. (2015). Energie : économie et politiques. De Boeck, seconde édition, 2015.

Jouvet, P-A. and Solier, B. (2013). An overview of CO_2 cost pass-through to electricity prices in Europe. Energy Policy, volume 61, pp. 1370-1376, October 2013.

Li, H., Maddala, G.S. and Trost, R. (1996). Estimation des élasticités de court et de long termes de la demande d'électricité sur données de panel à partir d'estimateurs à rétrécisseur. Economie & prévision, volume 126 (5), pp. 127-141, 1996.

Réseau de transport de l'électricité (RTE) et Agence de l'environnement et de la maîtrise de la demande d'énergie (Ademe). (2016). Signal prix du CO_2. Analyse de son impact sur le système électrique européen, Mars 2016.

Réseau de transport de l'électricité (RTE). (2016). Bilan électrique 2015 et Bilan prévisionnel de l'équilibre offre-demande d'électricité en France. Edition 2015.

Roques, F. and Le Thieis, Y. (2016). Impact assessment of the introduction of a CO_2 price floor in France and in Europe. Compass Lexecon, June 2016.

Trotignon, R., Jouvet, P-A., Solier, B., Quemin, S. and Elbeze, J. (2015). European carbon market: lessons on the impact of a market stability reserve using the Zephyr model. Working Paper n°2015-11 de la Chaire Economie du Climat.

Trotignon, R., Solier, B. and De Perthuis, C. (2015). Un prix-plancher du carbone pour le secteur électrique : quelles conséquences ?, Policy Brief n°2015-03 de la Chaire Economie du Climat, Novembre 2015.

Appendix 1 – The ZEPHYR-Elec model

The ZEPHYR-Elec model is a simulation model for short-term supply/demand equilibrium in the electricity sector. It was developed in the standard version to represent four countries (France, UK, Germany and Poland), totalling more than half of the installed generating capacity in Europe.

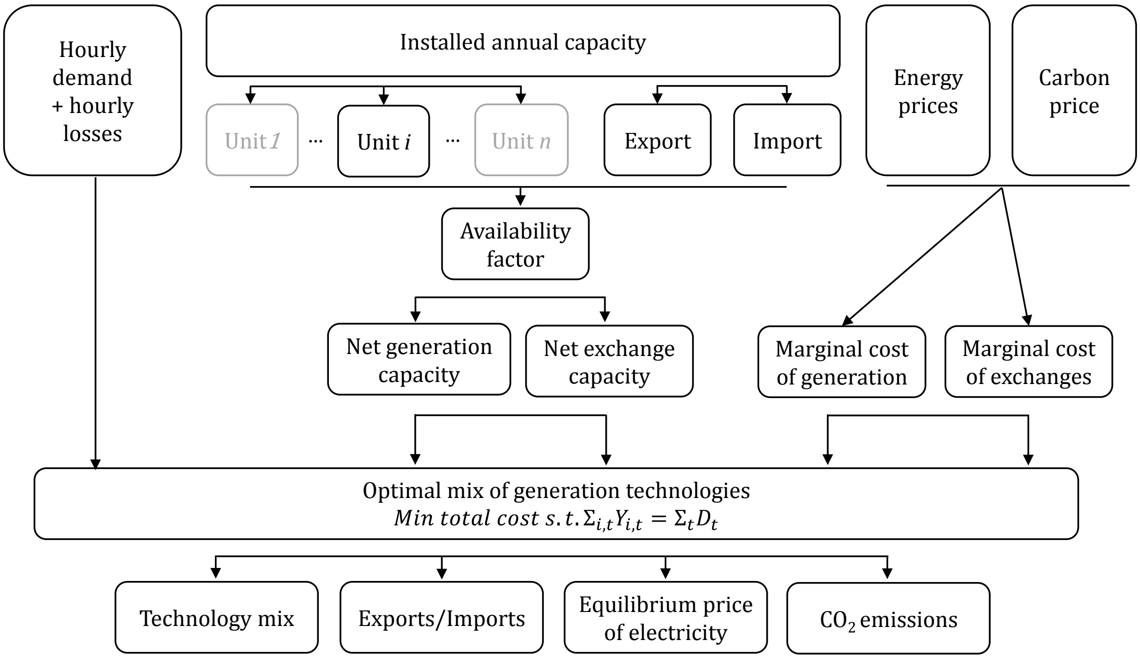
For each of the 8,760 hours of the year, the model determines the combination of generating technologies enabling electricity demand to be met at least cost, fixed exogenously, given the marginal costs of production and the available generation and interconnection capacities. It then determines, for each hour, the electricity mix, volumes traded, CO_2 emissions and the equilibrium price of electricity corresponding to the last technology called on.

The representation of the electricity supply in the model is based on a technological approach in which the means of production are considered to be homogeneous within the same production group. Each technology is assigned a marginal cost of production determined, in the case of thermal production facilities, by the net cost of energy inputs, augmented by the cost associated with net CO_2 emissions. So-called renewable technologies such as solar, wind or run-of-river hydro, are assigned a zero marginal cost and are therefore called on as a priority in the model. Specific treatment was given to dam hydropower, whose use in the model is determined according to a use value corresponding to the production cost of the thermal electricity it replaces.

Exchanges in the model are represented by means of interconnection capacities to which marginal costs are allocated. Imports are represented by two types of "borders", which inject electricity into the model when the marginal costs of production are close to those of coal and gas respectively. Export capacity was introduced in the form of a third "border" that will increase national means of production when the marginal costs are close to those of nuclear power.

Demand in the model is obtained by the sum of hourly power demand during the 8,760 hours of the year, to which are added the hourly losses linked to electricity transmission. In addition, to represent solely centralized power generation subject to a carbon price, the hourly output from decentralized production capacities (mainly gas and oil co-generation plants) was removed from demand. This treatment resulted in the discrepancies between total production in the model and observed production, as well as deviations from the average price of electricity.

Operating diagram of the ZEPHYR-Elec model



APPENDIX 2 – SENSITIVITY ANALYSIS OF ENERGY PRICES

Energy prices scenarios	Baseline	Energy prices 2016	High gas – Low coal	Low gas – High coal
		Equilibria without floor price		
Domestic electricity generation	533.6 TWh	533.6 TWh	533.6 TWh	533.8 TWh
Coal	8.6 TWh	8.6 TWh	8.6 TWh	1.3 TWh
Gas CCGT	12 TWh	12 TWh	12 TWh	19.5 TWh
Electricity imports	29.6 TWh	29.6 TWh	29.6 TWh	29.4 TWh
Total emissions	36.3 $MtCO_2$	36.3 $MtCO_2$	36.3 $MtCO_2$	23 $MtCO_2$
Domestic	13.4 $MtCO_2$	13.4 $MtCO_2$	13.4 $MtCO_2$	9.5 $MtCO_2$
Imported	22.9 $MtCO_2$	22.9 $MtCO_2$	22.9 $MtCO_2$	13.6 $MtCO_2$
Average price of electricity	€33.2/MWh	€25.9/MWh	€36.1/MWh	€24/MWh
		Net effects of a 30€/tCO_2 floor price France		
Domestic electricity generation	-14.5 TWh	-14.8 TWh	-9.3 TWh	-13.1 TWh
Coal	-5.6 TWh	-7.3 TWh	0 TWh	0 TWh
Gas CCGT	-8.9 TWh	-7.5 TWh	-9.3 TWh	-13.1 TWh
Electricity imports	+14.5 TWh	+14.8 TWh	+9.3 TWh	+13.1 TWh
Total emissions	-2.8 $MtCO_2$	-3.7 $MtCO_2$	+0.2 $MtCO_2$	+1.2 $MtCO_2$
Domestic	-8.7 $MtCO_2$	-9.7 $MtCO_2$	-3.5 $MtCO_2$	-5.0 $MtCO_2$
Imported	+5.8 $MtCO_2$	+5.9 $MtCO_2$	+3.7 $MtCO_2$	+6.2 $MtCO_2$
Average price of electricity	+€3.2/MWh	+€2.6/MWh	+€3.4/MWh	+€2.6/MWh
		Energy price assumptions		
Average coal price	€51/t	€42/t	€40/t	€60/t
Average natural gas price	€20/MWhp	€13/MWhp	€25/MWhp	€10/MWhp

Note: This table shows simulations of electricity sector equilibrium and of the impact of a price floor in France of €30/tCO_2 under different gas and coal price scenarios. The "Energy prices 2016" scenario corresponds to simulations implemented by considering the average daily gas and coal prices observed from early January to late May 2016. Two additional scenarios were tested by considering different combinations of gas and coal prices (see Figure 5, section 2.4).

APPENDIX 3 – A SENSITIVITY ANALYSIS IN TERMS OF THE FLOOR PRICE

Floor price scenarios	Baseline	Floor price €20/tCO_2	Floor price €30/tCO_2	Floor price €56/tCO_2
Domestic electricity generation	533.6 TWh	524.1 TWh	519.1 TWh	518.8 TWh
Coal	8.6 TWh	8.3 TWh	3.0 TWh	1.3 TWh
Gas CCGT	12 TWh	2.7 TWh	3.1 TWh	4.5 TWh
Electricity imports	29.6 TWh	39.2 TWh	44.1 TWh	44.4 TWh
Total emissions	36.3 MtCO2	36.4 MtCO2	33.5 MtCO2	32.6 MtCO2
Domestic	13.4 MtCO2	9.6 MtCO2	4.8 MtCO2	3.7 MtCO2
Imported	22.9 MtCO2	26.7 MtCO2	28.7 MtCO2	28.8 MtCO2
Average price of electricity	€33.2/MWh	€35.2/MWh	€36.4/MWh	€39.1/MWh
Effects of a floor price France				
Domestic electricity generation	–	-9.5 TWh	-14.5 TWh	-14.8 TWh
Coal	–	-0.3 TWh	-5.6 TWh	-7.3 TWh
Gas CCGT	–	-9.3 TWh	-8.9 TWh	-7.5 TWh
Electricity imports	–	+9.6 TWh	+14.5 TWh	+14.8 TWh
Total emissions	–	0 MtCO_2	-2.8 MtCO_2	-3.8 MtCO_2
Domestic	–	-3.8 MtCO_2	-8.7 MtCO_2	-9.7 MtCO_2
Imported	–	+3.8 MtCO_2	+5.8 MtCO_2	+5.9 MtCO_2
Average price of electricity	–	+€2/MWh	+€3.2/MWh	+€5.9/MWh
CO_2 price and energy price assumptions				
Prix moyen du CO_2 FR	€8/tCO_2	€20/tCO_2	€30/tCO_2	€56/tCO_2
Prix moyen du CO_2 EU	€8/tCO_2	€8/tCO_2	€8/tCO_2	€8/tCO_2
Prix moyen du Charbon	€51/t	€51/t	€51/t	€51/t
Prix moyen du Gaz Naturel	€20/MWhp	€20/MWhp	€20/MWhp	€20/MWhp

Note: This table shows simulations of electricity sector equilibrium and the impact of a French floor price for different introductory levels, respectively €20/tCO_2, €30/tCO_2 and €56/tCO_2.

APPENDIX 4 – COAL PHASE-OUT SCENARIO UNDER A REGULATORY MEASURE

Scénarios		Baseline	Floor price France	Regulatory measure
Domestic electricity generation		533.6 TWh	519.1 TWh	527.9 TWh
	Coal	8.6 TWh	3.0 TWh	0 TWh
	Gas CCGT	12 TWh	3.1 TWh	14.9 TWh
Electricity imports		29.6 TWh	44.1 TWh	35.3 TWh
Total emissions		36.3 MtCO2	33.5 MtCO2	31.7 MtCO2
	Domestic	13.4 MtCO2	4.8 MtCO2	6.5 MtCO2
	Imported	22.9 MtCO2	28.7 MtCO2	25.2 MtCO2
Average price of electricity		€33.2/MWh	€36.4/MWh	€34.7/MWh
Effects on equilibrium				
Domestic electricity generation		–	-14.5 TWh	-5.7 TWh
	Coal	–	-5.6 TWh	-8.6 TWh
	Gas CCGT	–	-8.9 TWh	+2.9 TWh
Electricity imports		–	+14.5 TWh	+5.7 TWh
Total emissions		–	-2.8 $MtCO_2$	-4.6 $MtCO_2$
	Domestic	–	-8.7 $MtCO_2$	-6.9 $MtCO_2$
	Imported	–	+5.8 $MtCO_2$	+2.3 $MtCO_2$
Average price of electricity		–	+€3.2/MWh	+€1.5/MWh
CO_2 price and energy price assumptions				
Prix moyen du CO_2 FR		€8/tCO_2	€30/tCO_2	€8/tCO_2
Prix moyen du CO_2 EU		€8/tCO_2	€8/tCO_2	€8/tCO_2
Prix moyen du Charbon		€51/t	€51/t	€51/t
Prix moyen du Gaz Naturel		€20/MWhp	€20/MWhp	€20/MWhp

Note: This table shows simulations of electricity sector equilibrium resulting from the adoption by the public authorities of a regulatory measure to decommission French coal plants. In the model this involves giving zero generation capacity to coal plants and comparing, at unchanged calibration, the results to the baseline scenario.

APPENDIX 5 – THE ZEPHYR-EU ETS MODEL

The ZEPHYR-EU ETS model is a simulation model of the annual supply-demand equilibrium of CO_2 allowances. It is based on the period 2005-2014 and allows this equilibrium to be projected for the period 2015-2020.

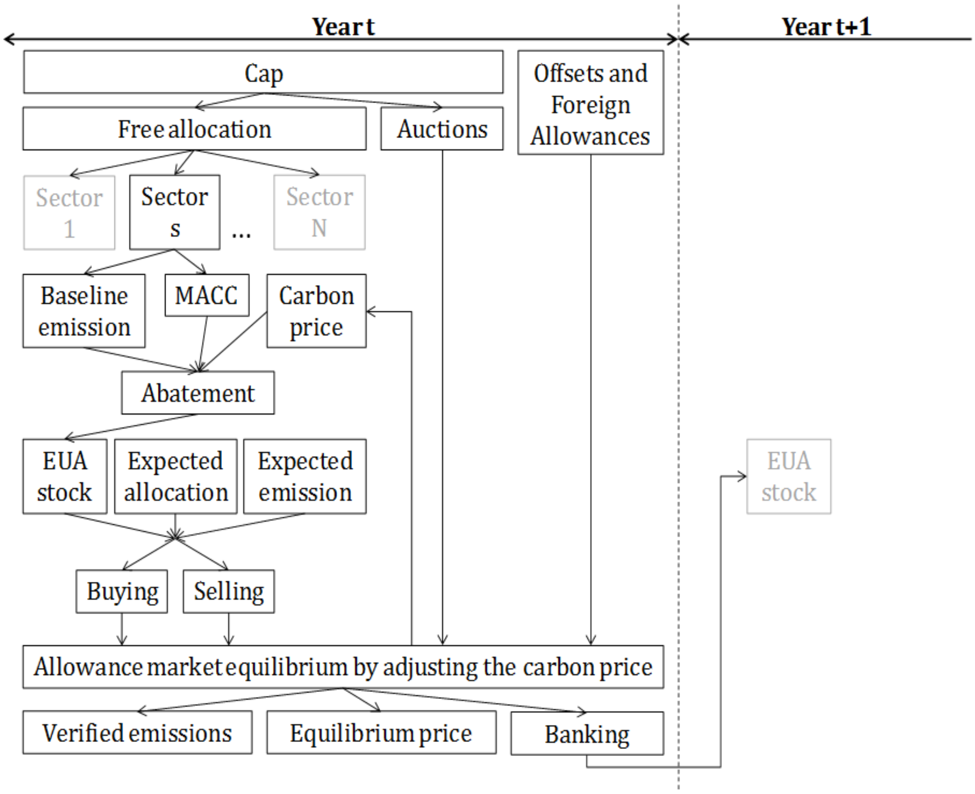
Ten sectors are represented: power generation (with national distinctions for France, Germany, the United Kingdom and Poland), other combustion, refineries, iron & steel, cement, and other industries. These sectors are characterized by a baseline emissions growth (i.e. growth in the absence of a carbon price) related to a GDP growth scenario and by a marginal abatement cost curve (MACC), which describes the relationship between the carbon price in the market and the emissions of the sector concerned. The areas have access to free allocations and auctions that are represented and projected according to global reduction targets (progressive reduction of the allowances cap).

The model also includes a representation of expectations: each sector anticipates its future position and takes into account this information in its compliance behaviour. Several scenarios can be tested through an exogenous expectation parameter. Thus every year actors can thus sell or buy allowances based on their current and expected position in the market (see flow diagram below).

At every moment the emissions of the various sectors are determined at the intersection between the marginal abatement curve and the price of carbon. The model thus considers that the actors instantly react to the opportunity cost associated with the carbon price by reducing all emissions whose cost is lower than that price.

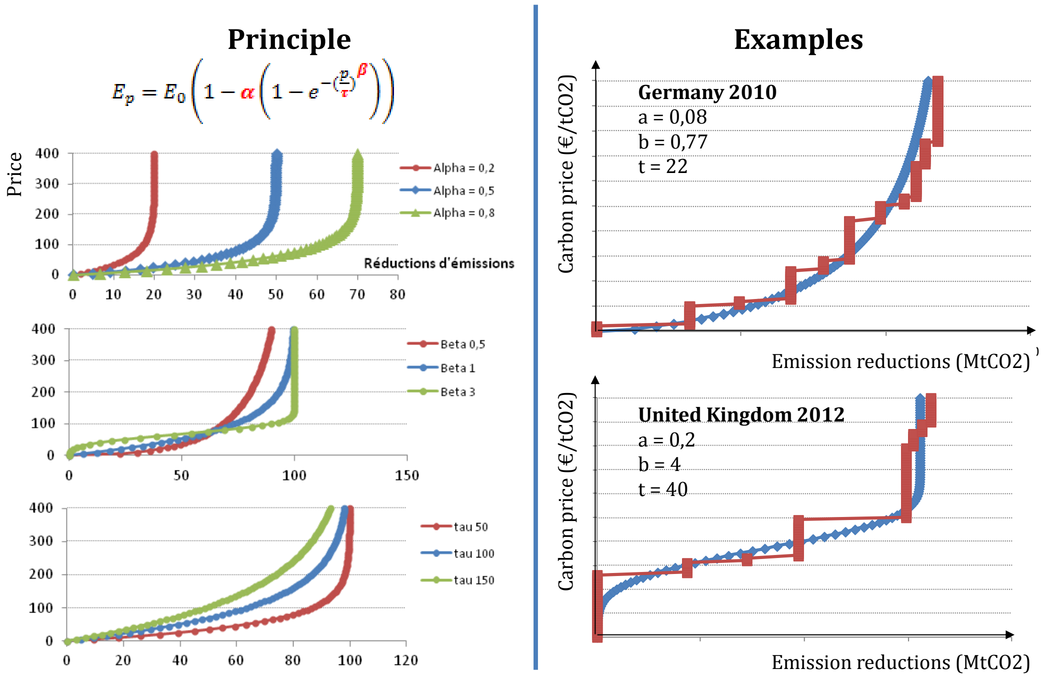
Each year, the model calculates the lowest carbon price that can satisfy an equilibrium between allowance supply and demand, taking into account banked allowances that are carried over to the following period.

Operating diagram of the ZEPHYR-EU ETS model



Source: Chaire Economie du Climat

Representation of the marginal abatement costs in ZEPHYR-EU ETS



Source: Chaire Economie du Climat

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