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Impact assessment of the introduction of a CO2 price support in France and Europe

CONFÉRENCE SUR LE PRIX PLANCHER DU CO2 ET RÉFORME DE L'EU ETS – LES IMPACTS SUR LE SECTEUR ELECTRIQUE

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Context and scope

Context and scope of the analysis

- **The French government announced its intention to implement a carbon price support in order to reduce the carbon emissions from the power sector.**
  - "The aim is to reduce the running hours of coal (resp. gas) power plants from 4,000 hours (resp. 1,700 hours) to 200 hours (resp. 500 hours). It will save 12 million CO2 tons per year." *Governmental source* *
- **To analyse the impact of the introduction of such a Carbon price support, FTI-CL Energy modelled a range of carbon price scenarios using its proprietary model of European power markets.**
  - We modelled a range of CO2 prices from €15/tons to €35/tons, assumed flat from 2017.
  - Applied either to all plants in Europe, to all plants in France, or only to coal plants in France.
  - The relevant indicators we derive from our model are thermal generation, net export balance, CO2 emissions and average power prices.
- **The deck is structured in four sections:**
  - Introduction: The French and European theoretical marginal cost of coal and gas plant;
  - In-house power market model presentation;
  - Results from the impact assessment of a European Carbon price floor @ 30/tCO2;
  - Results from the impact assessment of a range of French Carbon price floor.

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** Source: Le Monde: Pourquoi Hollande propose-t-il un prix du plancher du carbone, 26 avril 2016.*

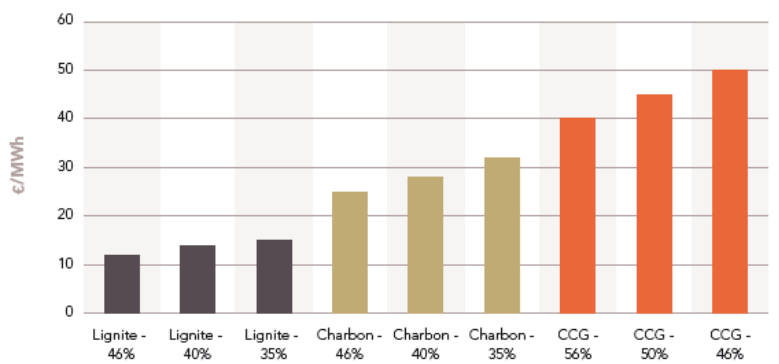
Introduction:
Marginal cost of French and European coal and gas plants with French CO2 price support

European marginal cost (SRMC) of coal and gas plants with different carbon prices

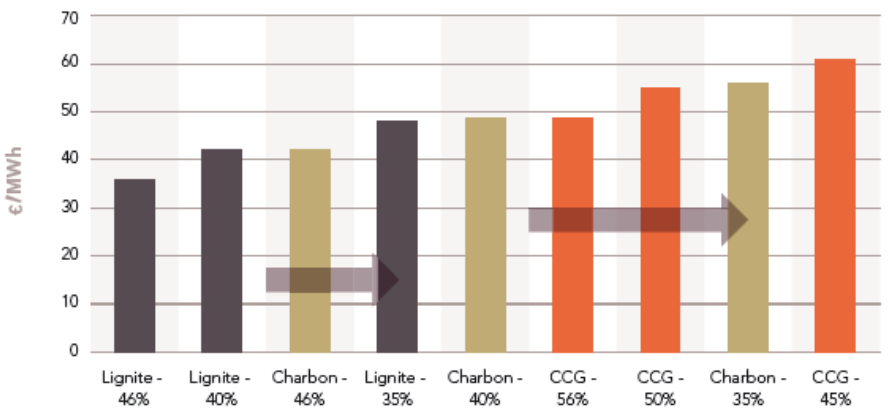
Theoretical impact on SRMC

- Under current market conditions, coal plants marginal cost of production are lower than CCGT marginal cost of production.
- In RTE & ADEME impact assessment analysis from March 2016, marginal cost of production of Lignite, coal and gas plants are compared for different construction vintage and different efficiencies.
- The analysis highlights:
  - The wide range of marginal cost of production; and
  - The impact of a higher CO2 price on the SRMC ranking.
- Note: The analyses assumes a gas cost of €6.7/Mbtu, a coal cost of €87/tons, a gas carbon content of 0.208 CO2T/MWh, a coal carbon content of 0.344 CO2T/MWh

SRMC @ 7€/CO2 tons



SRMC @ 30€/CO2 tons



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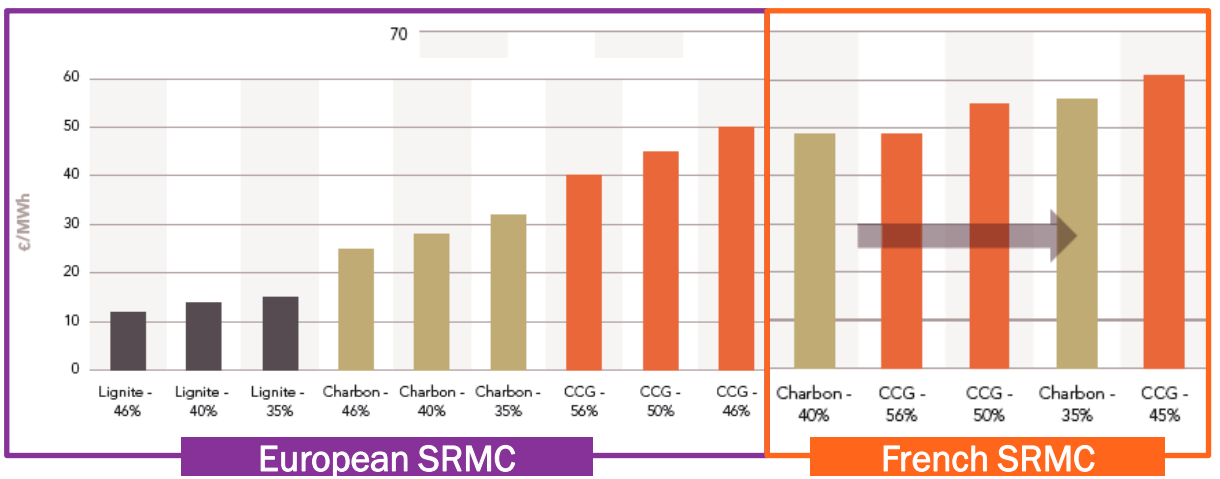
Source: Etude de RTE et ADEME sur le prix carbone, mars 2016

French vs. European marginal cost (SRMC) of coal and gas plants with French CO2 price support

Theoretical impact on SRMC

- The introduction of a French CO2 price support would negatively impact the French coal and gas power production versus the other European power stations.
- Indeed, given the technical parameters of the French coal and gas power plants, their marginal cost of production would get higher than in neighbouring countries.
- The chart below ,made of the two previous RTE/ADEME charts, illustrates the new SRMC merit order between French and other European power plants.
- Both French thermal generation are pushed out of the European merit order – while French coal baseload generation would be reduced at the expense of exports to Belgium, GB, Spain and Italy, French semi-base / peak generation capability would be displaced by additional thermal imports from Germany, and neighbouring countries.

French SRMC @ 30€/CO2 tons vs European SRMC @7€/ CO2 tons



Source: Etude de RTE et ADEME sur le prix carbone, mars 2016

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FTI-CL European power market model

FTI-CL European power market model covers the power markets of the North-West Europe and calculates prices in each price zone

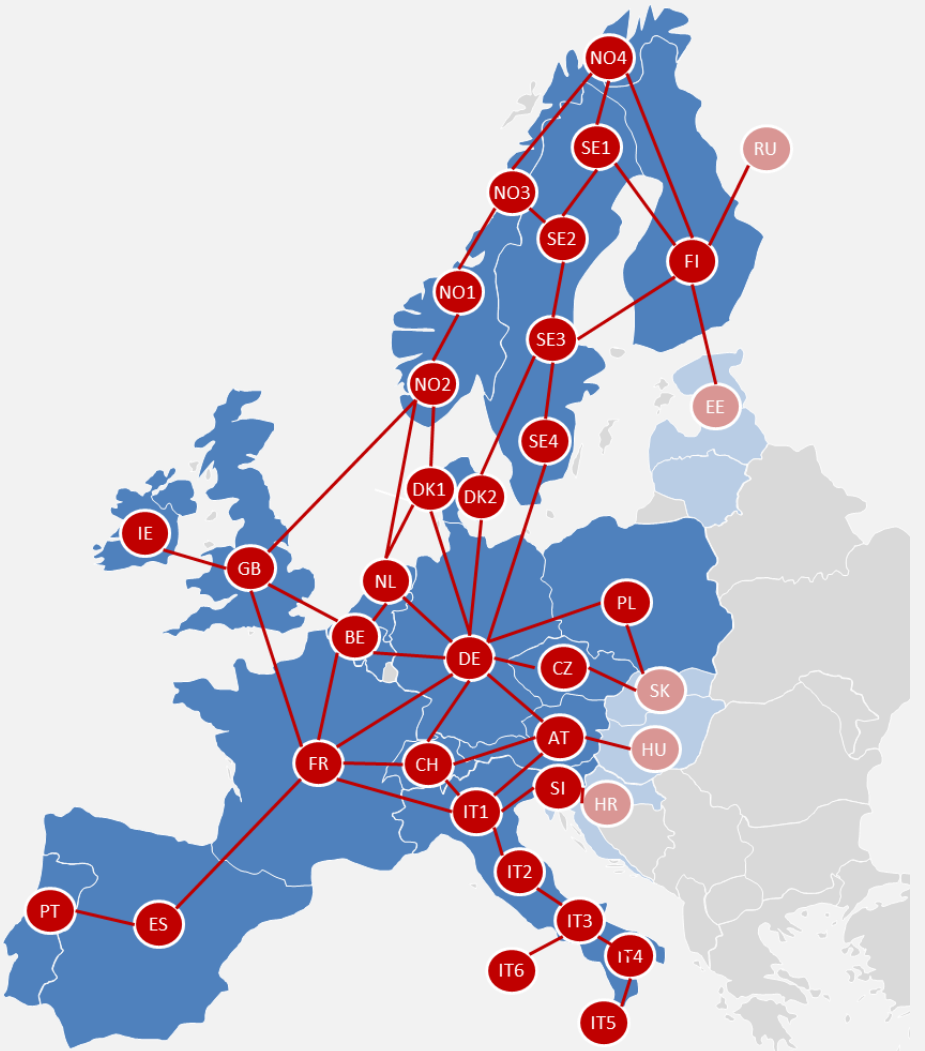
Geographic scope

- The model covers the West European Power markets:
  - GB and Ireland
  - France, Germany, Belgium, Switzerland, Austria and the Netherlands
  - Spain, Portugal and Italy
  - Denmark, Norway, Sweden and Finland

Model structure

- The model constructs supply in each price zone based on individual plants
- Zonal prices are found as the marginal value of energy accounting for generators' bidding strategies
- Takes into account the cross-border transmission and interconnectors and unit-commitment plant constraints
- The model is run on a commercial modelling platform Plexos®
  using data and assumptions constructed by FTI-CL Energy

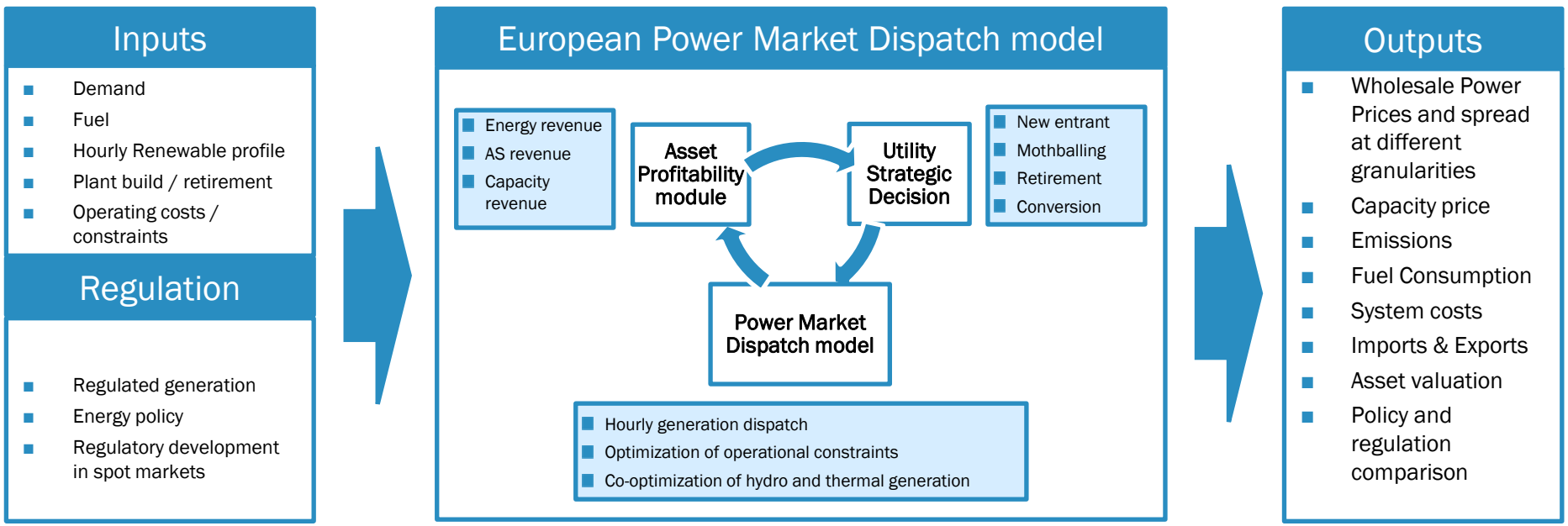
Model geographic scope



FTI-CL European power market model

Modelling approach

- At the heart of our market modelling capability lies a dispatch optimization software based on a detailed representation of market supply and demand fundamentals at an hourly granularity.
- We run our power scenarios on Plexos, a commercially available power market modelling software. It is globally used by regulators, TSOs, and power market participants.
- Our power market model is specifically designed to model renewable generation:
  - Wind: Hourly profiles are derived from our in-house methodology that converts consolidated wind speeds into power output.
  - Solar: Hourly profiles are derived from our in-house methodology that converts solar radiation into power output.
  - Hydro: Weekly natural inflows are derived from our in-house methodology that convert rainfall, ice-melt and hydrological drainage basin into energy.
  - Hydro: Generation is derived from a state-of-the-art hydro thermal co-optimization algorithm embedded at the heart of Plexos.



FTI-CL European power market model key assumptions and CO2 price support scenarios

Key assumptions and CO2 price floor scenarios

- FTI-CL European power market model key assumptions are derived from a number of sources:
  - Thermal generation outlook: ENTSOE forward looking scenarios cross-checked with the latest operators/regulators announcements;
  - Nuclear generation outlook: National policies objectives
  - Renewable generation outlook: National policies objectives cross checked with manufacturers pipelines
  - Power demand outlook: ENTSOE forward scenario cross checked with latest regulator ad TSO publications
  - Commodity outlook: Forward commodity prices linearized towards IEA long term commodity scenarios.

- In this impact assessment, we have developed tailored CO2 price outlooks to replicate a range of CO2 price support levels applied to power producers:

European CO2 price floor

Counterfactual scenario

All European thermal power producers are subjected to a CO2 price at forwards levels (between 6 and 7 €/tons)

European CO2 price floor @30€/tons

All European thermal power producers are subjected to a CO2 price of 30€/tons

French CO2 price floor

Counterfactual scenario

All European thermal power producers are subjected to a CO2 price at forwards levels (between 6 and 7 €/tons)

French CO2 price floor @15-35 €/tons

All French thermal power producers are subjected to a CO2 price ranging from 15-35€/tons

French CO2 price floor @30 €/tons on coal plants

All French CCGT operators are exempted from the CO2 of 30€/tons applied to French coal plants

European CO2 Price support impact assessment – FTI-CL European power market results

European CO2 Price support: we find a strong impact on thermal power plant generation

EU ETS and CPS @ 30€/tons scenario comparison

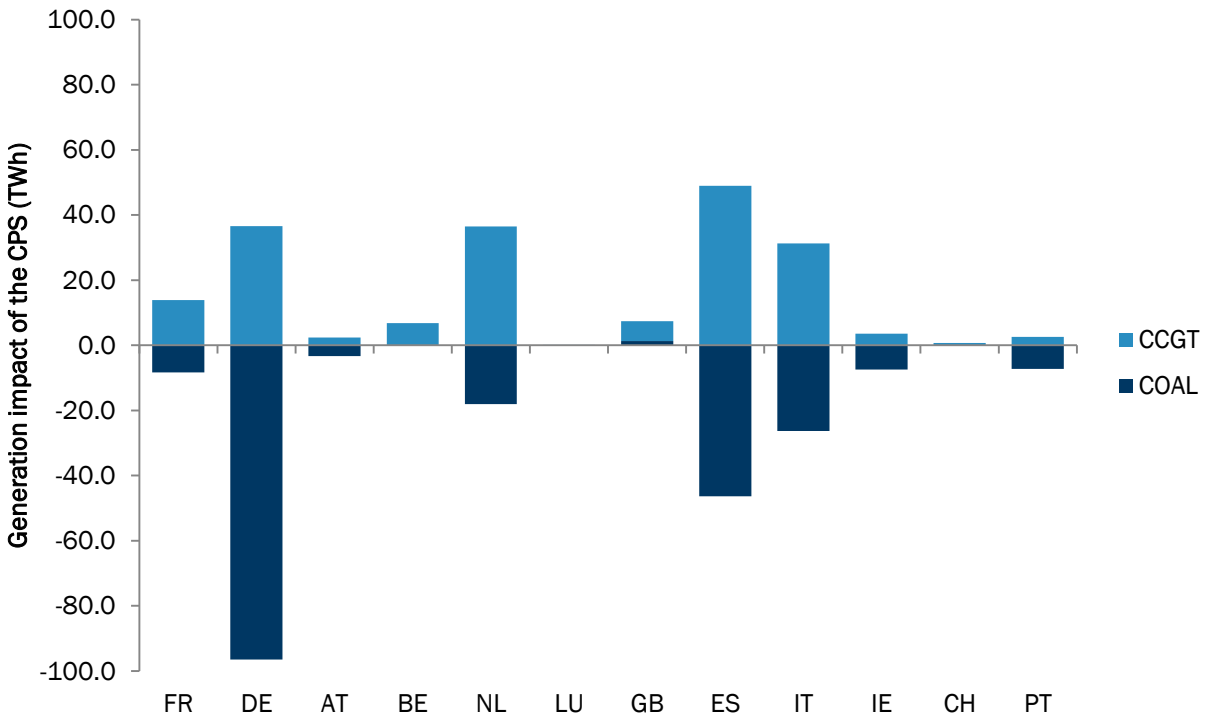
- Implementing a CPS throughout European would significantly impact the generation of coal and CCGT plants across Europe.
- The significant reduction of coal generation (200TWh) would be replaced by an increase of gas generation.

Results discussion

Assumption:

- In the EU ETS scenario, the carbon price is assumed to be at 6.1€/tons.
- In the CPS scenario, the carbon price is assumed to be at 30€/tons.
- Both are applied to all thermal generation using a gas carbon content of 0.179 ton/MWh and a coal carbon content of 0.315 ton/MWh

Generation change with the implementation of a CPS @30€/tons



European CO2 Price support : we find a strong impact on power flows across countries

EU ETS and CPS @ 30€/tons scenario comparison

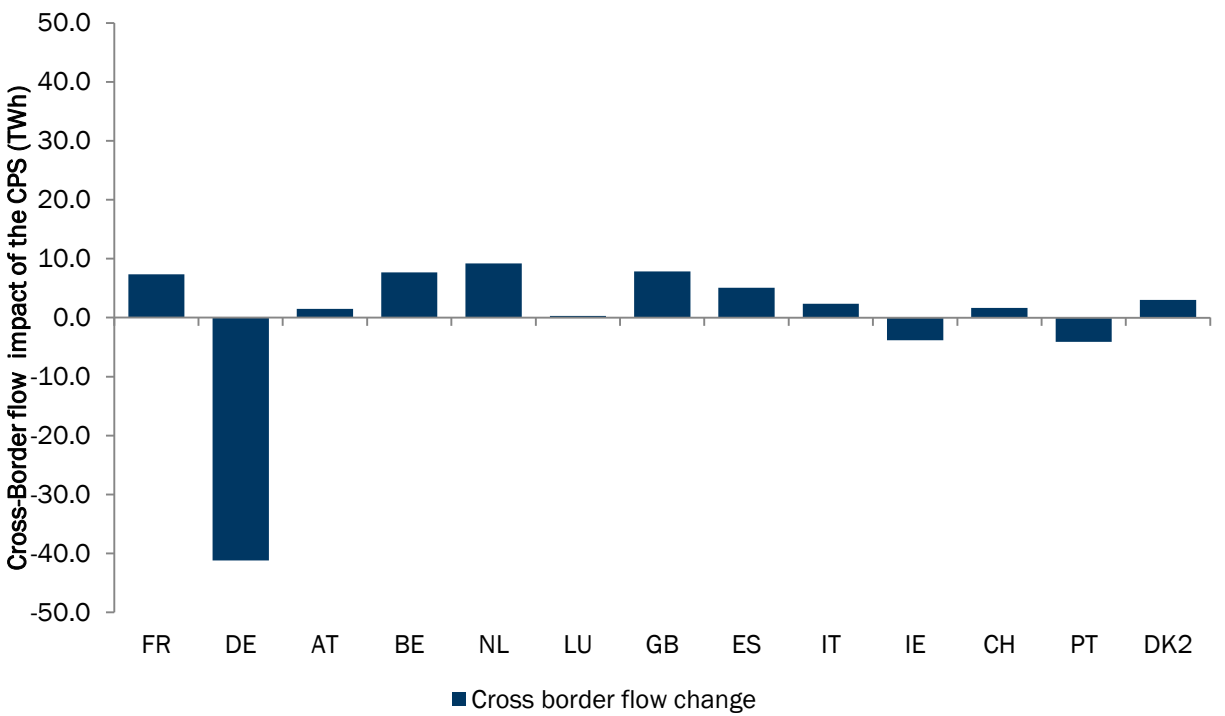
- Implementing a CPS throughout European would significantly impact the cross border flows.
- While most net export balance would benefit from the CPS, it would be at the expense of the German net exporter status.

Results discussion

Assumption:

- The net export balance change offset the asymmetrical impact on coal and gas generation shown in the previous slide.
- While for most of the countries the gas generation increase totally offset the coal generation decrease, the German market acts as a generation buffer and concentrate the asymmetrical impact of the CPS implementation.
- Note: While Nordic countries are modelled dynamically, flows with external countries are assumed fixed at historic levels.

Net export change with the implementation of a CPS @30€/tons



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European CO2 Price support: we find a strong impact on CO2 emissions

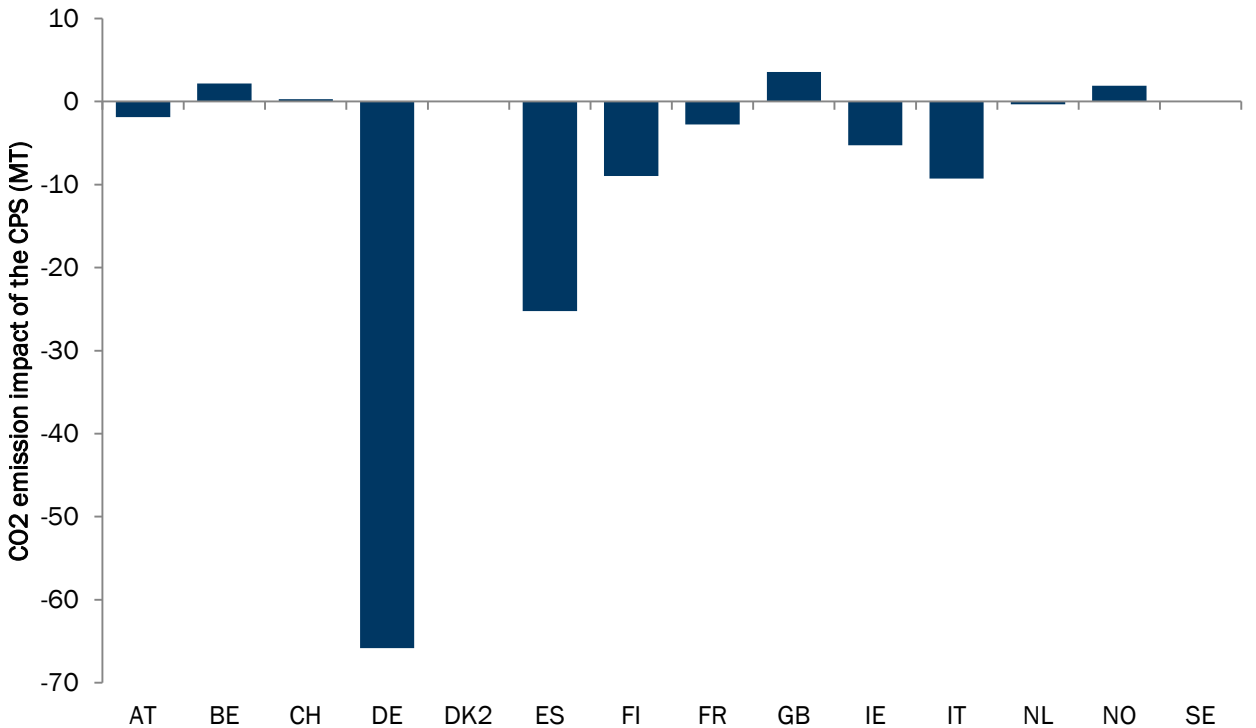
EU ETS and CPS @ 30€/tons scenario comparison

- Implementing a CPS throughout European would significantly reduce the CO2 emissions from the power sector.
- While Germany would see the highest CO2 reduction, some countries such as GB or BE would see a slight increase.

Results discussion

- German domestic CO2 emission reduction is directly related to the asymmetrical impact of the CPS on German power production.
- While most other countries see a net domestic CO2 reduction, some other see a net domestic increase. This is directly related to the higher domestic production and the lower reliance on cross-border flows.
- Overall, CO2 emission would decrease by c110Mtons of which c60% would come from German CO2 savings and c20% from Spanish CO2 savings.

CO2 emission change with the implementation of a CPS @30€/tons



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European CO2 Price support : we find a strong impact on average power prices

EU ETS and CPS @ 30€/tons scenario comparison

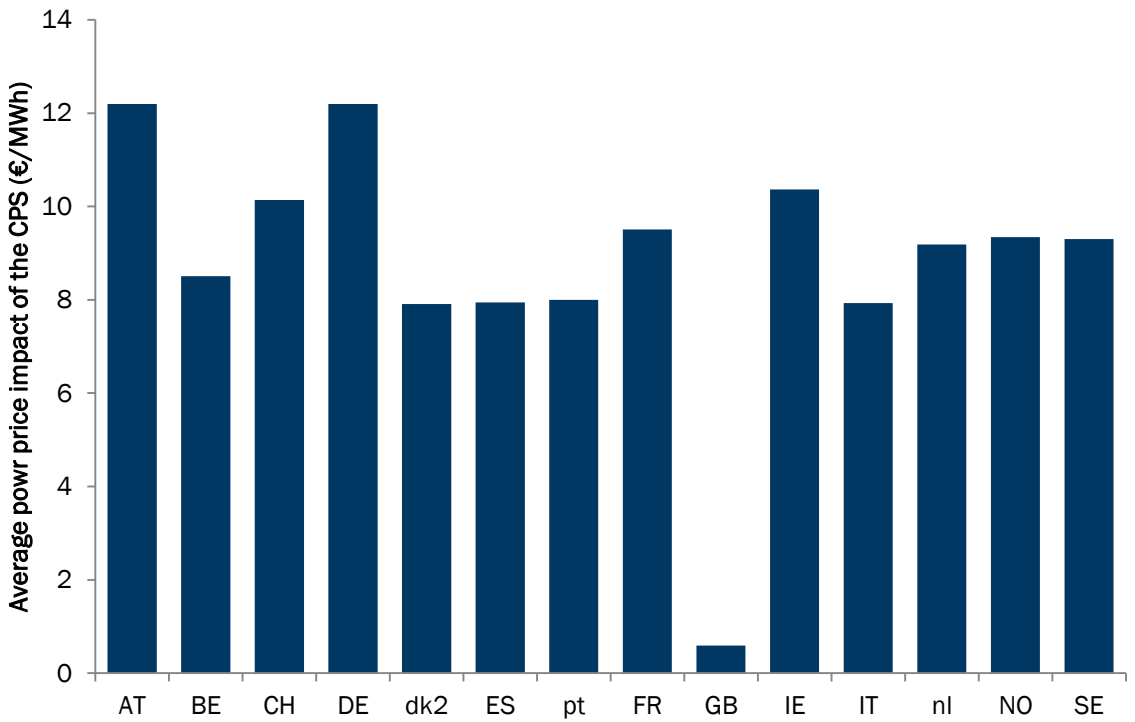
- Implementing a CPS throughout European would significantly impact the average power prices.
- In line with the impact on marginal cost of production, the average power price would increase by c10€/MWh.

Results discussion

Assumption:

- The impact of a CPS @30€/tCO2 ranges between 1 and 12€/MWh
  - Indeed, the GB being already subject to the UK CPF, we assume that GB CO2 price remains at current levels. The impact comes from the cross border flows.
  - Germany would have a more expensive marginal technology and get closer to other NWE power markets.
  - Nordic water value would increase in line with the SRMC of other technologies.

Average power price change with the implementation of a CPS @30€/tons



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French CO2 Price support impact assessment – FTI-CL European power market results

French CO2 Price support : we find a strong negative impact on French thermal power plant generation

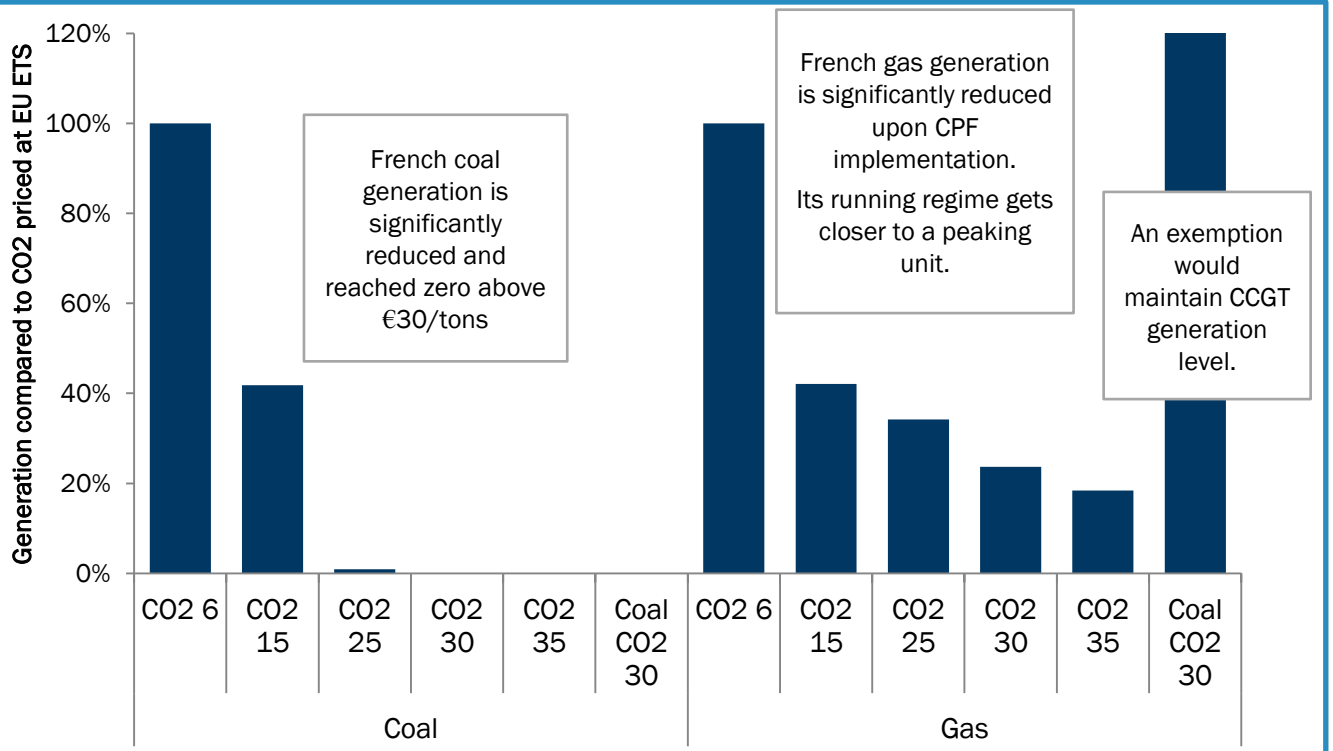
EU ETS and French CPS scenario comparison

- Implementing a unilateral CO2 Price support (CPS) in France would significantly impact the French thermal generation.
- Coal generation would be hardly above 0 with a high CPS; CCGT generation would be negatively impacted unless they a re granted an exemption.

Results discussion

- To assess the impact of a CPS implementation on French thermal generation we used a range of CPS prices leading to the fuel switch above €30/tCO2.
- French coal generation is significantly reduced and reaches zero above €30/tons
- French gas generation is significantly reduced upon CPF implementation. Its running regime gets closer to a peaking unit.
- An exemption from the CPS for CCGTs would maintain CCGT generation level.

Generation change with the implementation of a French CPS



FTI-CL Coal CO2 30 scenario refers to the scenario where CCGTs are exempted from the CO2 price support while coal are subject to a CO2 price floor of €30/tons.

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French CO2 Price support: we find a negative impact on the French net export balance

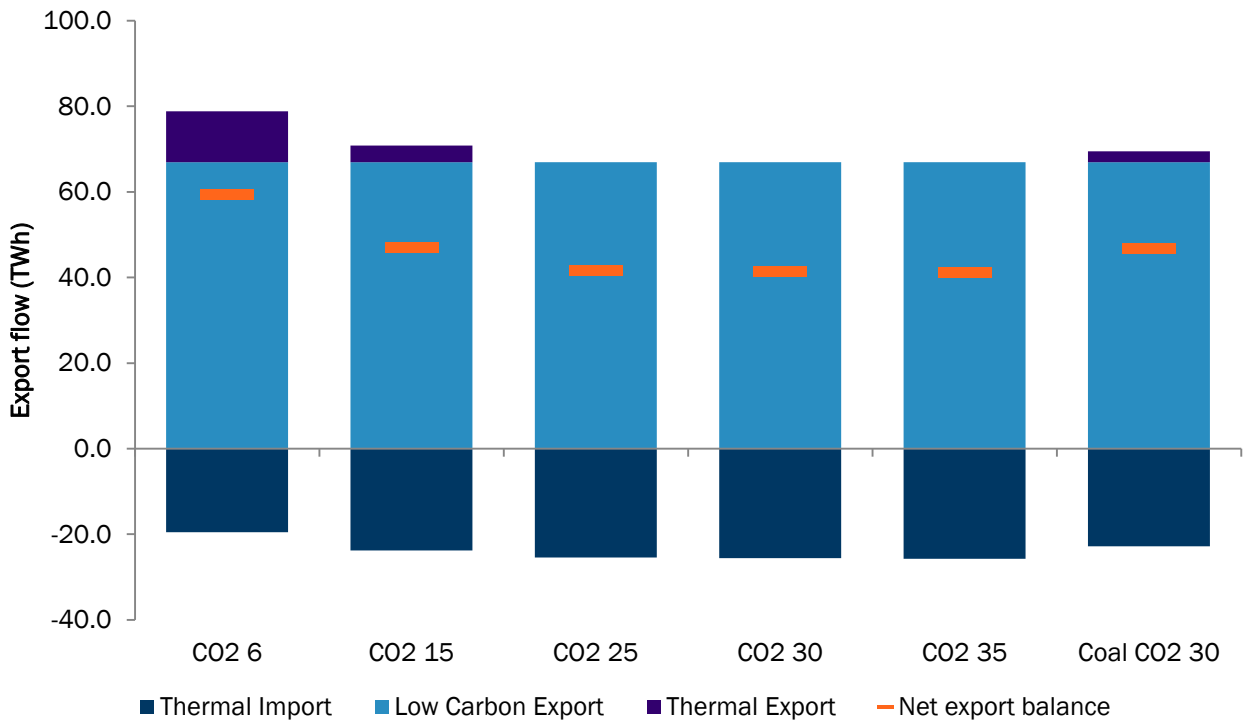
EU ETS and French CPS scenario comparison

- Implementing a unilateral CPS in France would significantly impact the French net export balance.
- Overall, the net export balances could reduce by 20TWh (c400€m) per year from by 2017.

Results discussion

- The CPS affects cross border flows:
  - French coal generation is reduced, which reduces the thermal exports to neighbouring countries.
  - French gas generation is reduced, which increases the reliance of the French power system on imports to balance the power system in high demand periods.
- Overall, the net export balance could reduce by 400€m per year from 1.4€bn to 1€bn by 2017.
- An exemption for CCGTs would partially offset this decrease and maintain the net export balance around 1.1€bn by 2017.

Cross-border flow change with the implementation of a French CPS



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French CO2 Price support: Impact on CO2 emissions

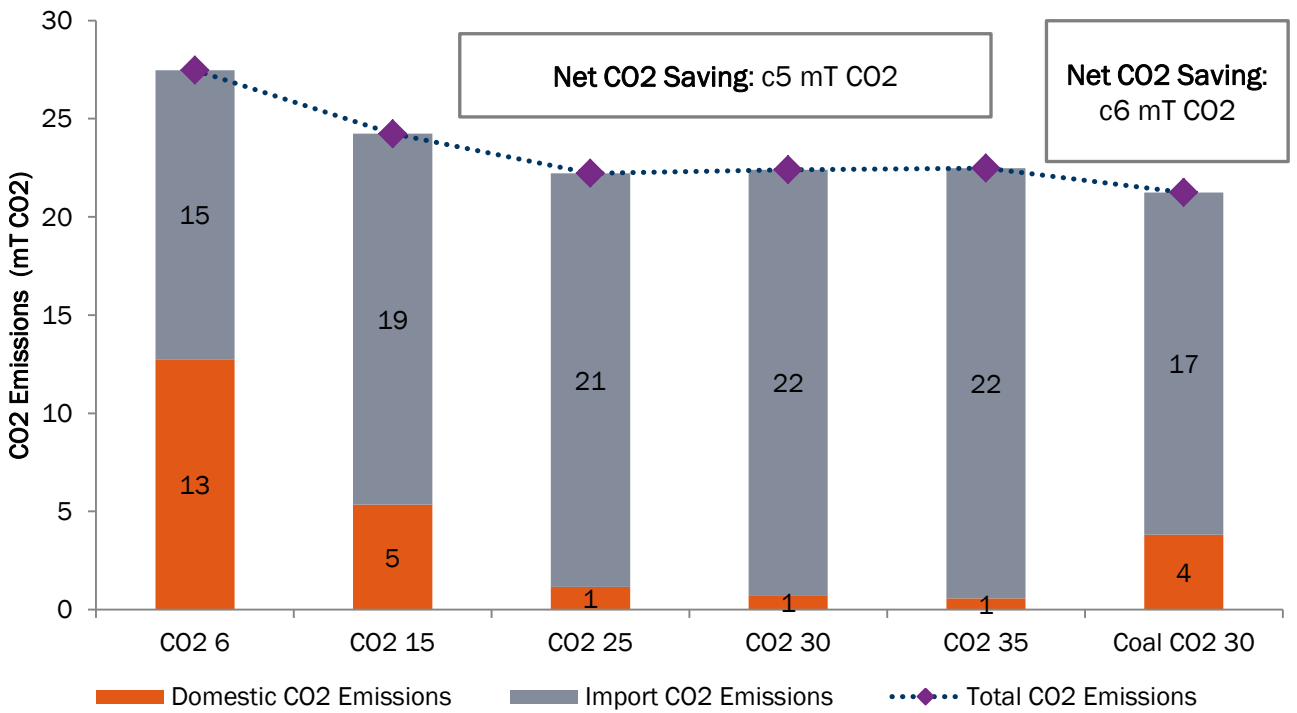
EU ETS and French CPS scenario comparison

- A unilateral CPS in France would reduce the domestic CO2 emissions by c12mT, but this would be partly offset by increased imported emissions of about 7mT.
- Overall, the net CO2 saving would be halved compared to the domestic savings.

Results discussion

- While a French CPS could save up to 12 CO2 million tons from French power generation, about half of this saving would be offset by increased imports from German coal and other imports.
- An exemption on CCGT, would slightly reduce the CO2 domestic reduction but increase the overall French system saving as CCGT would replace carbon intensive imports.

CO2 emission change with the implementation of a French CPS



Domestic CO2 emissions refer to CO2 emissions from coal and CCGTs power station

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French CO2 Price support: impact on power prices

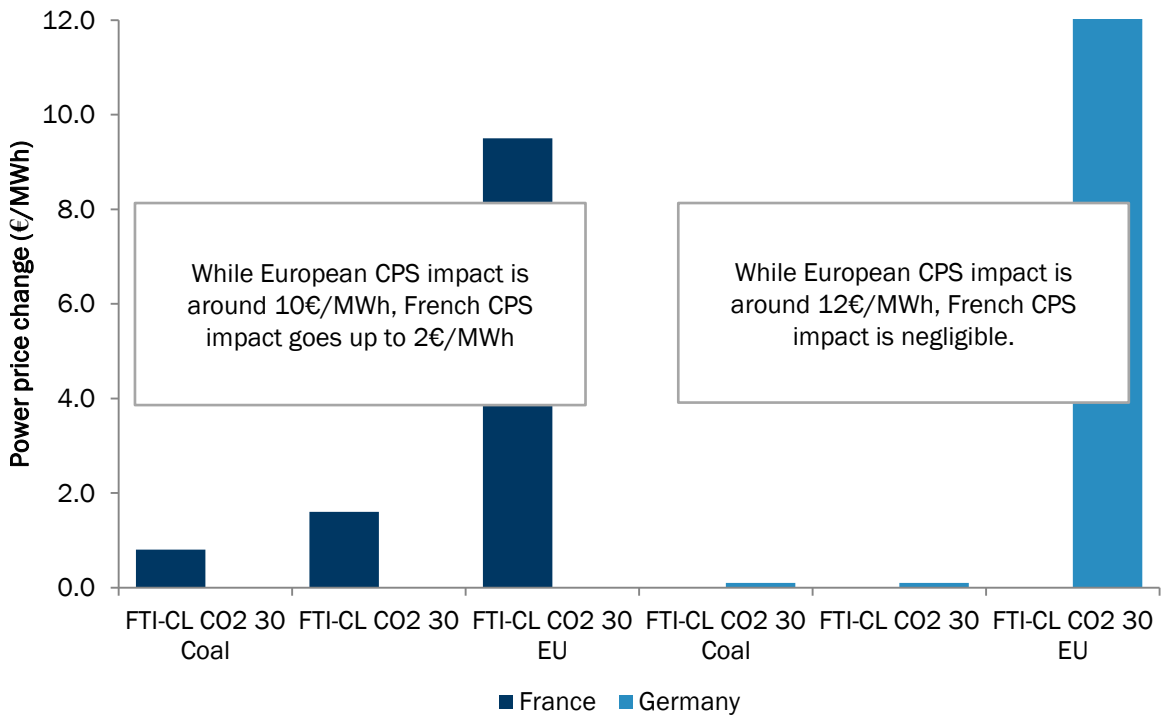
EU ETS and French CPS scenario comparison

- Implementing a unilateral CPS in France would increase prices up to 2€/MWh or 900m€ per year.
- This increase could be halved by an exemption on CCGT.

Results discussion

- French customers would pay €900 millions per year for 12 million tonnes saved from French power generation or 5 million saved from a system wide basis.
- Overall French customers would pay €75-€180/tons* for each CO2 tonnes saved.
- An exemption on CCGT would bring this cost down to c€1/MWh or 450m€ a year in 2017. French customers would pay €50-75/tons* for each CO2 tonnes saved.

Average power price change with the implementation of a French CPS



These computations are based on the additional cost paid by customers divided by domestic or net CO2 savings. However, a net saving per saved CO2 tons analysis would require to include additional cost components such as the savings derived from operational cost differences between coal plants and CCGTs.

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