

Study Committee C5

Electricity Markets and Regulation

Paper 10235_2022

CARBON PRICING AND WHOLESALE ELECTRICITY MARKETS – KEY IMPACTS AND TRENDS FROM AROUND THE WORLD

Anthony GIACOMONI¹, Diego ALVARADO², Livia AMORIM³, Kenneth BRUNINX⁴, Brian JOSEPH⁵, Anes KAZAGI⁶, Rodrigo MORENO⁷, Subhendu MUKHERJEE⁸, Yoann THOMAS⁹, Jarrad WRIGHT¹⁰

PJM Interconnection¹, Instituto Sistemas Complejos de Ingeniería², Souto Correia³, KU Leuven⁴, Ernst & Young⁵, EPRI⁶, University of Chile⁷, POSOCO⁸, EDF⁹, CSIR¹⁰

Motivation

- Due to increased concerns over climate change, many countries and jurisdictions around the world are implementing carbon pricing schemes to limit greenhouse gas (GHG) emissions.
- According to the World Bank, as of June 2022, there were 68 explicit carbon pricing initiatives implemented or scheduled for implementation around the world that cover over 23% of global GHG emissions.

Background

- There are two main archetypes of carbon pricing: 1) emissions trading systems (ETSs) and 2) carbon taxes.
- An ETS – sometimes referred to as a cap-and-trade system – caps the total level of GHG emissions. Tradeable emissions permits or allowances are issued, facilitating cost-effective abatement: each emitter makes the trade-off between abatement or paying for an emission allowance. By creating supply and demand for emission allowances an ETS establishes a market price. The cap ensures the required emissions reductions will take place to keep the emitting resources (in aggregate) within their pre-allocated emissions budget.
- A carbon tax directly sets a price on GHG emissions by defining a tax rate on GHG emissions or – more commonly – on the carbon content of fossil fuels with or without allowances.

Objects of Investigation

- While other studies such as those by the World Bank provide an overview of existing and emerging carbon pricing initiatives, this paper focuses specifically on their impacts on wholesale electricity markets and the electric power sector in selected regions. Several questions that are addressed in this paper include the following:
 - What explicit carbon prices and companion policies currently impact wholesale electricity markets in each region?
 - How has the carbon price changed over time and what was the reason for the change?
 - How has it benefited or hurt certain supply-side resources/technologies and has it created any reliability concerns?
 - What are the impacts of carbon leakage and what approaches have been taken to mitigate leakage such as border adjustments?

Survey

- Countries and regions across all six continents were analyzed including Australia, Bosnia and Herzegovina, Brazil, Chile, China, the European Union (EU), India, Japan, the Russian Federation, South Africa and the United States of America (US).

Carbon Pricing Initiatives

- Of the 11 regions studied, five currently include or included at one time an ETS, four include a carbon tax and two do not include any carbon pricing mechanism. For the Australian National Electricity Market (NEM), an ETS existed from 1 July 2012 to 1 July 2014 before it was repealed.

Table 1: Carbon Pricing Initiatives with Impacts on their Wholesale Electricity Markets for each of the Regions Studied

Emissions Trading System (ETS)	Carbon Tax	No Carbon Pricing
Australia - NEM	Bosnia and Herzegovina	Brazil
China - Guangdong Province	Chile	Russian Federation
European Union	Japan	
India	South Africa	
US - PJM Interconnection		

³Brazil has no carbon pricing policy in place with impacts on the wholesale electricity market. There is a carbon pricing policy in place, RenovaBio, but its scope is restricted to the reduction of emissions by fossil fuels from fuel distribution companies, mostly focused on the transportation sector. Currently, the Brazilian Congress is discussing Bill n.º 528/2021, which proposes the creation of the "Brazilian Market for Emissions Reduction".

Conclusion

- Over the last decade, with few exceptions, there have been persistent low carbon prices across each of the carbon pricing initiatives studied. Exceptions:
 - Australia NEM's carbon price prior to 1 July 2014, when it was repealed
 - EU-ETS carbon price beginning in March 2018
 - US-Regional Greenhouse Gas Initiative (RGGI) carbon price beginning in December 2021
- Impacts on wholesale electricity markets, to date, have been minimal, with the exception of the EU.
- The implementation of the carbon price can be very important.
- All regions studied have been very successful in implementing companion policies aimed at reducing carbon emissions, which have contributed to the low carbon prices.
- Few regions have implemented any measures to mitigate carbon leakage.

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Carbon Pricing Historical Trends

- A comparison of the carbon prices for the nine carbon pricing initiatives listed in Table I from October 2012 – June 2022 is shown in Figure 1.
- The carbon prices determined by an ETS are shown in solid lines and those determined by a carbon tax are shown in dashed lines.
- The 2021 EU-ETS price rally shown in Figure 1 may be attributed to market participants anticipating more stringent emission targets, such as those currently under discussion in the context of the Fit for 55 package.



Figure 1: Comparison of carbon prices², October 2012 – June 2022 (ETS – solid line, carbon tax – dashed line).

²To aid in the comparison of different monetary values, all monetary values were converted to euros per ton CO₂e, using the exchange rates in effect on 1 August 2020.

Companion Policies

- Of the 11 regions studied, eight currently have policies related to energy efficiency, four have electric transportation initiatives, eight have renewable portfolio standards (RPS) and all 11 have additional legislation related to reducing GHG emissions.

Table II: Companion Policies for each of the Regions Studied

Market Region/Country	Energy Efficiency	Electric Transportation Initiative	Renewable Portfolio Standards (RPS)	Other Legislation
Australia - NEM			X	X
Bosnia and Herzegovina	X		X	X
Brazil	X	X		X
Chile	X	X	X	X
European Union	X	X	X	X
China - Guangdong Province			X	X
India	X	X	X	X
Japan			X	X
Russian Federation	X			X
South Africa	X			X
US - PJM	X		X	X

Carbon Pricing Initiative Impacts

Australia – National Electricity Market (NEM)

- Carbon price repealed with effect from 1 July 2014.
- The impact of the repeal was immediately noticeable on real-time wholesale electricity market prices as shown in Figure 2.

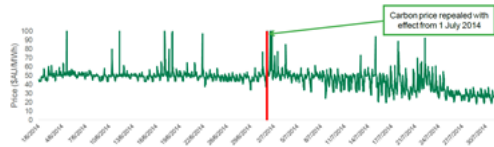


Figure 2: Real-time prices between 0 – 100 \$AU/MWh in New South Wales, 1 June 2014 – 31 July 2014.

Bosnia & Herzegovina

- Impacts of the electricity tax charged to power generation from coal (considered as an *explicit* carbon tax):
 - Transition from electricity produced by fossil fuel (coal) to renewable energy sources has been accelerated due to the increased cost of energy from fossil fuel (coal) sources.
- Impacts of the carbon pricing design for Energy Community members:
 - Introduction of carbon pricing renders coal uneconomic beginning in approximately 2030 onwards, in both scenarios with full market integration.
 - If market fragmentation continues and conditions favoring gas supply are not in place, coal remains in the system after 2030 despite its high costs.

Chile

- Carbon tax has primarily affected carbon-emitting thermal generators, as most of the tax is paid by them.
- Side-payment rule introduced by the regulator requires the payment of compensations by other generators, thus affecting other technologies, including renewable energy sources.
- Studies suggest that the current market design may hinder the development of renewable generation in the country.

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China

- **Reverse carbon leakage:** a shift in emissions from a non- or less-constrained region to a carbon-constrained one.
- Study concluded that the China ETS pilots do lead to reverse carbon leakage between the pilot regions and the non-pilot regions.
- One possible explanation is that market pressure in the pilot markets is low. This implies that emitters receive so many free emissions allowances that they can expand their production scales accordingly resulting in more emissions and reverse carbon leakage in the pilot provinces.

European Union

- 2019 decrease in carbon emissions from coal:
 - Hard coal carbon emissions decreased by 30%
 - UK reduced its carbon emissions from hard coal by 6.5 million tons (41%)
 - Germany reduced its carbon emissions from hard coal by 22 million tons (28%)
 - Poland reduced its carbon emissions from hard coal by 12 million tons (16%)
 - Lignite carbon emissions decreased by 25%
- Despite European Union Allowance (EUA) prices near 100 €/t-CO₂, due to the recent increase in natural gas prices coal-fired electricity generation is now cheaper than gas-fired generation.

Table III: Ranges of European Union Allowance (EUA) Prices That Could Trigger Decarbonisation Actions in the European Power Sector

EUA price for fuel switch (€/tCO ₂)	Hard coal-fired power plants to CCST	CCST to Nuclear (+ battery capacity, flexibility...)	CCST to Renewables (+ battery, capacity, flexibility...)	CCST to Carbon Capture and Storage (CCS)	CCST to Biogas	CCST to e-gas
0-20	None	None	None	None	None	None
20-40	None	None	None	None	None	None
40-60	None	None	None	None	None	None
60-80	Hard coal-fired power plants	None	None	None	None	None
80-100	None	None	None	None	None	None
100-120	None	None	None	None	None	None
120-140	None	None	None	None	None	None
140-160	None	None	None	None	None	None
160-180	None	None	None	None	None	None
180-200	None	None	None	None	None	None
200-250	None	None	None	None	None	None
250-300	None	None	None	None	None	None
300-350	None	None	None	None	None	None
350-400	None	None	None	None	None	None

United States – PJM Interconnection

- PJM conducted a carbon pricing study to explore the impacts of a carbon price from RGGI on the PJM footprint in 2023.
- **Scenario 1:** Four states that participated in RGGI prior to 2022 (DE, MD, NJ, VA)
 - Impacts on energy market prices and total PJM CO₂ emissions are expected to be small.
- **Scenario 2:** Four states that participated in RGGI prior to 2022 + Pennsylvania (PA)
 - Impacts on energy market prices and total PJM CO₂ emissions are more significant.
 - As the carbon price approaches the effective ceiling price the impacts to the average energy price increase by over 10% (>3 €/MWh) and total PJM CO₂ emissions decrease by over 5%.

Carbon Leakage Mitigation

- Two of the initiatives (EU-ETS and US-RGGI) have implemented specific measures to mitigate carbon leakage while a third (Australia-NEM) had implemented specific measures before being repealed.
- Carbon leakage has the potential to diminish or in the worst case reverse the emissions reduction benefits of any implemented carbon pricing initiative and is an area of ongoing debate in many countries and regions although few approaches have yet been implemented.

Conclusion

- Over the last decade, with few exceptions, there have been persistent low carbon prices across each of the carbon pricing initiatives studied. Exceptions:
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- Impacts on wholesale electricity markets, to date, have been minimal, with the exception of the EU.
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- Few regions have implemented any measures to mitigate carbon leakage.

South Africa

- Dominant coal generation could potentially be impacted in the future but the current level of the carbon tax is so low before and after allowances that the impact is minimal.
- New-build carbon-intensive power generation like unabated coal is already uncompetitive even without a carbon tax.
- Increased carbon tax will further drive investments into less carbon intensive energy production.