ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

RAPPORTI

Emissions Trading Scheme in Italy and in the biggest European countries

Emissions and allowances

352/2021

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Autori

Antonio Caputo (ISPRA)

Contatti: Antonio Caputo
Tel. 0650072540
e-mail antonio.caputo@isprambiente.it

ISPRA- Istituto Superiore per la Protezione e la Ricerca Ambientale

Dipartimento per la valutazione, i controlli e la sostenibilità ambientale.
Area per la valutazione delle emissioni, la prevenzione dell'inquinamento atmosferico e dei cambiamenti climatici, la valutazione dei relativi impatti e per le misure di mitigazione e adattamento.
Sezione scenari di emissione, modelli integrati e indicatori.

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«Every civilization that appeared on Earth continued, even after extinction, to influence the course of human events. Indeed, sometime, the influence of extinct civilizations can be very strong.»
Arnold J. Toynbee, Mankind and Mother Earth: A Narrative History of the World, 1976.
(My translation from the Italian).

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EXECUTIVE SUMMARY

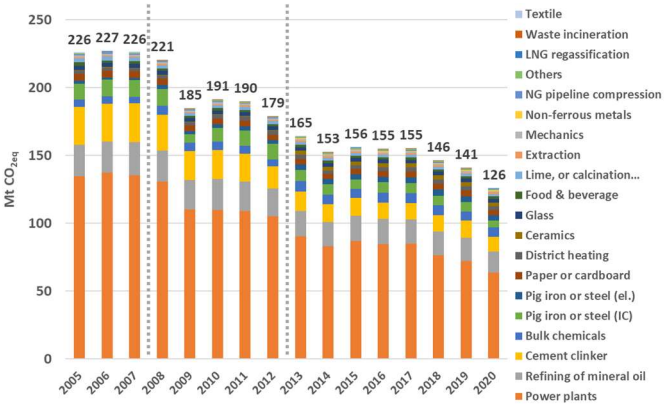
The EU-ETS is one of the pillars of European environmental policy to contrast climate change and is an essential market tool for reducing greenhouse gas emissions cost-effectively. At European level, it covers around 10,000 plants, as well as aircrafts operators, and about 40% of the EU's greenhouse gas emissions. In 2020, the European wide target is for the emissions from ETS sectors to be 21% lower than in 2005. Data show that verified emissions from the stationary installations in the EU ETS fell by 42.8% in 2020 compared to 2005, including the aviation emissions the reduction is 41.7%. In order to achieve the 2030 EU target (at least 55% GHG reductions compared to 1990), the ETS has been deeply revised and extended to maritime transport, road transport and buildings. The new ETS should reduce emissions by 61% compared to 2005 (43% for road transport and buildings), while the reduction for the Effort Sharing sectors, not affected by the ETS, will be 40% compared to 2005.

The achievement of the ETS emission reduction targets depends on the market balance between 'demand' of GHG emissions and 'supply' of carbon allowances, so the ratio between carbon allowances in circulation, especially freely allocated, and verified emissions is a decisive parameter for the functioning of the EU ETS and its effectiveness in reducing GHG emissions. The end of 2020 is the right time to make the final balance about the GHG emissions from ETS installations and the amount of free allowances in the 2nd and 3rd ETS phases in order to assess any allowances surplus and deficit among industrial sectors both in Italy and in the biggest European countries.

Italian data

ETS emissions account for an average of about 37% of total GHG emissions in Italy since 2005. Considering also the emissions estimated to reflects the current ETS scope, the share of ETS emissions in 2005 rises to 42% with a peak of 42.2% in 2007. Since 2005, there has been a decreasing trend of ETS emissions share up to about 33% in 2020, according to the provisional estimate of total GHG emissions.

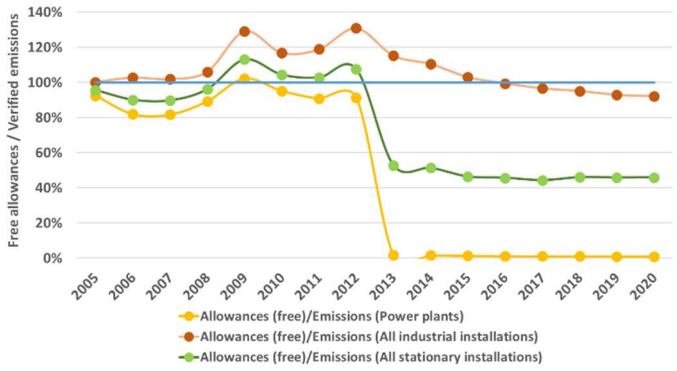
Power plants represent the predominant sector of ETS, exceeding 50% of ETS emissions in 2020. Power sector is followed by refining of mineral oil sector (12% of emissions) and cement clinker (9%). The emissions by bulk chemicals sector account for about 4%. The four sectors represent more than 75% of ETS emissions. The emissions share of these sectors decreased since 2005 to 2020 from 84.7% to 76.9%. There is a considerable heterogeneity concerning the emissions reduction. Considering the estimates to reflect the current ETS scope, the overall reduction in 2020 is 49.1% compared to 2005.



The emissions from industrial installations was 62.2 $MtCO_2eq$ in 2020, with an increasing share in recent years, from 45% of ETS emissions in 2013 to 49.4% in 2020. From 2005 to 2020 the share of power sector decreased from 59.5% to 50.6%.

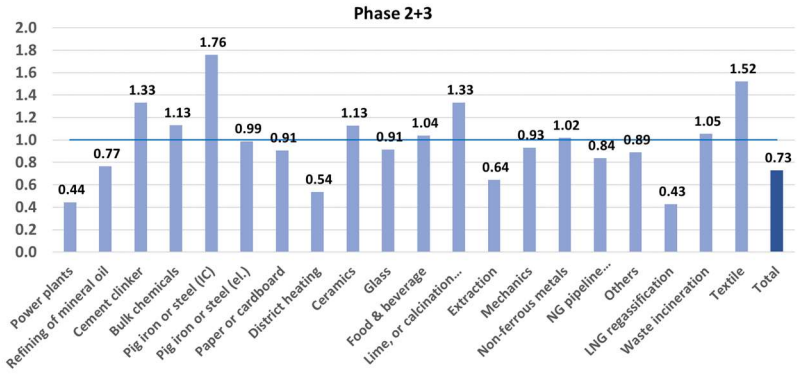
Most of the ETS emissions in Italy are due to a relatively small number of installations by sectors with the highest emissive intensity per plant, such as power plants, refining of mineral oil, cement clinker and integrated cycle pig iron or steel installations. Emissions are more "concentrated" in 2005 than in 2020. In 2005, the threshold of 95% emissions were reached by 31.4% of plants (296), while in 2020 the number of plants increased to 408 (41.9%). The average installation size, in other words the plant emissions intensity, decreased sensibly from 239.9±886.4 kt CO_2eq in 2005 to 129.4±414.9 kt CO_2eq in 2020. Power plants average intensity decreased from 981.5±1,841.2 kt CO_2eq to 490.8±744.8 kt CO_2eq

from 2005 to 2020, while industrial sectors decreased over the same period from 113.7±486.4 kt CO_2eq to 73.7±300.9 kt CO_2eq.

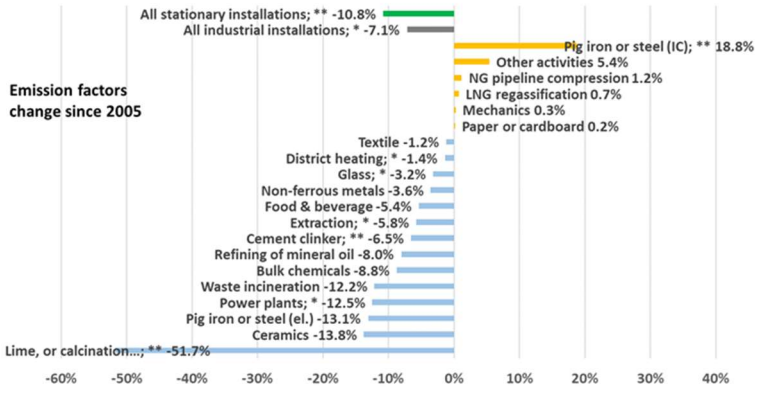


The ratio between free allowances and verified emissions allows to assess any surplus or deficit of allowances. A remarkable surplus of free allowances was recorded from 2009 to 2012 mainly due to the economic crisis which heavily reduced the production activities. The surplus concerned the industrial installations.

The ratios by sector between cumulative free allowances and cumulative verified emissions since 2008 highlight the sectors with surplus of free allowances which range from 1.8% for non-ferrous metals to 75.8% for integrated cycle pig iron or steel. The whole ETS system recorded deficit of free allowances of 27.1% with allowances surplus over than offset by the allowances demand from power sector.



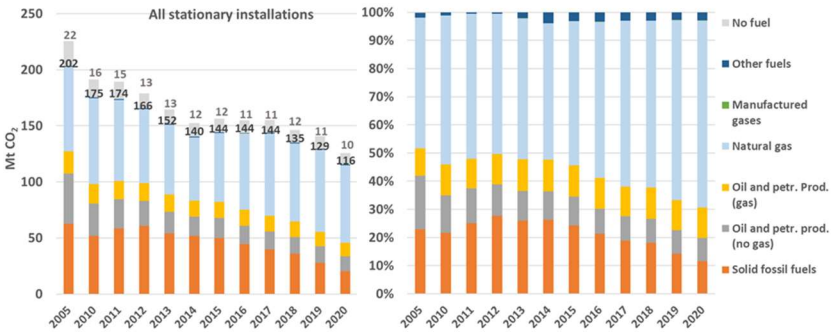
ETS energy consumption, from fossil fuels and bioenergy, amounted to 69.5 Mtoe in 2005, 36.7% of gross inland energy consumption. In 2020, ETS energy consumption fell to 44.5 Mtoe, 31.3% of provisional estimate of gross inland consumption. The ETS share decreased steadily, although with some fluctuations. The energy consumption fell by 36% from 2005 to 2020, while GHG emissions fell by 44.2% and in particular emissions by fuel consumption, which account for almost 92% of ETS emissions, fell by 42.9%.



The sectoral emission factors, given by the ratio of emissions to fuel energy content from fossil fuels and bioenergy, decreased significantly in the period 2005-2020 both for power plants and industrial installations. Some sector, as integrated-cycle pig iron or steel, recorded statistically significant increasing emission factors (+18.8% in 2020 compared to 2005). Overall, sectors showing an increase of the emission factors compared to 2005 account for 8.7% of ETS emissions in 2020.

The emission factors decrease is mainly explained by the decreasing share of energy consumption by fuels with higher carbon content as solid fossil fuels and no gaseous petroleum products (from 42.1% to 19.9% from 2005 to 2020) and the corresponding increase of natural gas share (from 46.6% to 63.3%). The power sector plays an important role in such fuel shift. The share of fuel energy consumption by natural gas increased from 54.2% in 2005 to 79.2% in 2020, while the share of solid fossil fuels and no gaseous petroleum products fell from 38.5% to 14.3%. Even in the industrial sectors there was a marked

increasing share of energy by natural gas, which raised from 32.8% to 50.8% in the period 2005-2020, and consequent decrease of energy by solid fossil fuels and manufactured gases (from 19.2% to 7.9%), as well as petroleum products other than gaseous ones (from 23.5% to 16.9%).



The trends of emissions by fuel and activity sector provide an insight concerning the potential to reach the emissions reduction in ETS sectors by 2030. According to the last Italian emission projections submitted by ISPRA to the European Commission in March 2021, prepared before the 'fit for 55' package proposals but reflecting the consequence of the Covid-19 pandemic, the ETS emissions projected in 2030 will be 123.0 $MtCO_2$ for the scenario with existing measures (WEM; -50.3% compared to 2005) and 95.7 $MtCO_2$ for the scenario with additional measures (WAM; -61.4% compared to 2005). The current ETS revision should result in an overall emission reduction of sectors under the EU ETS of 61% by 2030 compared to 2005. Appling such reduction to the current Italian ETS sectors the emissions from stationary installations in 2030 should be about 97 $MtCO_2$, about 26 $MtCO_2$ less than WEM scenario but of about 1 $MtCO_2$ above the WAM scenario. Such figures show clearly that Italy needs additional measures set up in the National Energy and Climate Plan to reach the new ETS target and that a crucial role will be played by power sector with the coal phase out by 2025 and the increase of renewable electricity up to 55% by 2030 from current 40%.

The fuel mix is not the only factor determining the emissions trend. An important role is also played by carbon content for each fuel concerning the fuel specific emission factors. The emission factors for fuel category as manufactured gases or gaseous petroleum products, as well as natural gas in power plants recorded significant decreasing trends since 2013.

Each industrial activity sector consumes a specific fuel mix related both to sector technology and production. The fuel mix can be very heterogeneous among sectors. Some sectors consume prevalently a single or few fuel categories, while other sectors have greater homogeneity among fuel categories with emissions from multiple sources. In some sector, as cement clinker and lime, the consumption of other fuels than fossils, mainly wastes and bioenergy, has increased significantly. Cement installations recorded a steady increase in the energy consumption share of such fuels that in 2020 met 21.0% of the sector energy demand. Installations in the lime sector met 49.4% of energy needs with solid biomass, while food & beverage sector met 15.7% of the energy needs of 2020 with biomass and wastes.

The regional distribution of installations shows higher concentration in the northern regions, especially Lombardy and Emilia Romagna. On the other hand, the emissions in the southern regions, such as Apulia and Sicily, show significant share despite the lower number of installations. The southern regions still in 2020 have higher share of emissions from power plants. The northern regions recorded the highest number of industrial installations despite a quite similar share of emissions with southern regions and islands (23.4% *vs* 20.5%). At national level there was 4.8% increase of industrial installation from 2005 to 2020, while the emissions decreased by 32%.

At national level, the emissive intensity per plant decreased by 46.1% since 2005, with higher reductions in the North-East and Centre. In the southern regions and islands, the emissive intensities are highest, with values ranging from 1.8 to 3.5 times the national average in 2020. The southern regions and the Islands registered the highest emissive intensities both for power plants and industrial installations due to plants powered by solid fossil fuels, mainly in Apulia and Sicily.

In the industrial plants the reduction of emissions by solid fossil fuels and oil or petroleum products is rather marked in every macro area, only in the southern regions there is a quite high share of emissions by solid fossil fuels as wells as the significant share of emissions by petroleum products in the Islands because of the presence of the pig iron installation in Apulia and the main refineries of mineral oil in

Sardinia and Sicily. Emissions from oil and no gaseous petroleum products show considerable reductions in all regions with few exceptions. The largest reductions are recorded for the power plants where the reduction since 2005 is near 100% in many regions and 96% at national level. The overall reduction in industrial sectors is 43.4% with southern and central regions showing larger reductions: 75.2% and 68.4% respectively.

The top five provinces with the highest ETS emissions are Taranto, Syracuse, Brindisi, Cagliari, and Rome with emissions from 9.3 to 5.7 $MtCO_2eq$ in 2020, 29.1% of total ETS emissions.

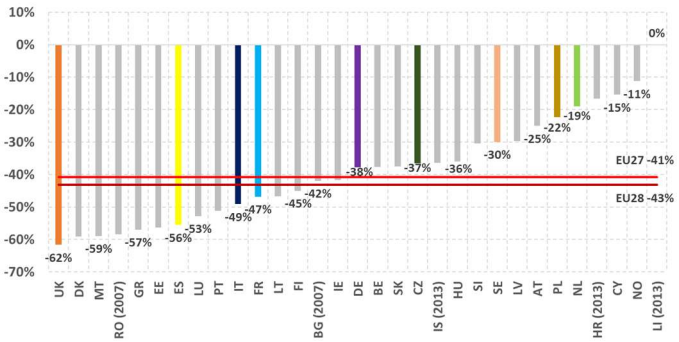
European data

The EU ETS involves currently 31 European countries, the 28 EU Member States (the effective exit of the United Kingdom from the European Union took place on 31 December 2020) plus Norway, Iceland and Lichtenstein.

ETS emissions amount to 1,355 $MtCO_2eq$ in 2020 (-42.8% compared to 2005). The reductions for EU28 and EU27 since 2005 are respectively 43.2% and 40.7%. The ETS emissions share in total GHG emissions of EU28 decreased from 44.7% in 2005 to 37% in 2019. In 2020 all activities were affected by lockdown due to SARS-CoV-2 pandemic.

The top four ETS emitting countries (Germany, Poland, Italy, and the United Kingdom) account for more than 50% of total ETS emissions (53.1% in 2005 and 53.4% in 2020). Such share did not change significantly since 2005, although the relative constancy is the result of the increasing share for Germany and Poland and the decreasing share for Italy and the United Kingdom. The top eight ETS emitting countries are responsible for more than 75% of total ETS emissions (75.5% in 2020). Considering also ETS emissions from Sweden the share rises to 76.7%.

Countries show a wide range of emission reduction rates in 2020 compared to their year of entry into the ETS. The reductions in the main countries range from 19% in the Netherlands to 61.6% in the United Kingdom. The next three countries with higher reductions, below the overall average (42.8%), are recorded for Spain (55.5%), Italy (49.1%), and France (46.8%).



Among the biggest countries the UK, Spain and Italy have the highest average annual emission reduction rates, from 4.4% to 6.2%. France and Germany recorded annual reduction rates of 4.1% and 3.1%, respectively. At the lower end the Netherlands recorded the lowest average annual reduction of 1.4%.

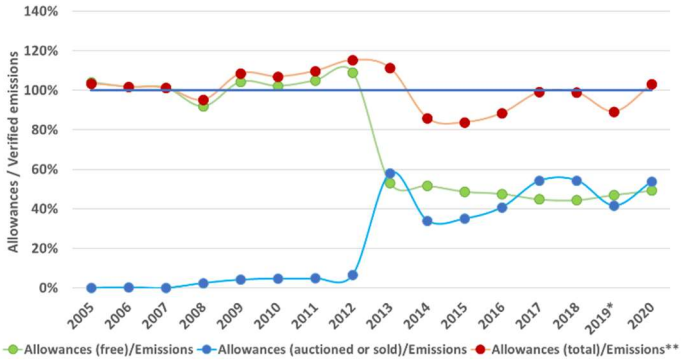
The emissions reduction is mainly due to combustion of fuels installations which reduced overall emissions by 43.1% since 2005. Industrial installations do not show a clear trend of emissions reduction, except from 2009 to 2012 when the effect of the economic crisis contracted the economy activities in many countries and consequently reduced emissions from industrial sectors. From 2005 to 2020, industrial installations reduced the emissions by 6.5%. However, it should be considered the role of economic activities lockdown in 2020 to contain the diffusion of SARS-CoV-2 pandemic. Since 2013 only few sectors recorded statistically significant trends of emissions decrease: combustion of fuels, refining of mineral oil, pig iron and steel, and coke. At country level the only countries, among the biggest, with statistically significant decreasing trends of emissions from industrial installations since 2013 are Italy, United Kingdom, and France.

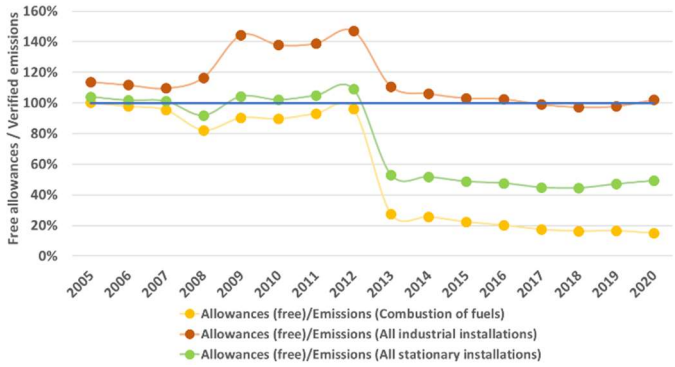
The combustion of fuels installations account for the majority of ETS emissions, with 60.6% in 2020. The emissions from such sector are mainly due to the power sector for electricity and heat production. Industrial activities such as cement clinker, refining of mineral oil, and pig iron or steel followed with respectively 8.4%, 8.4% and 7.8% of ETS emissions. The other industrial activity sectors have much

lower shares, from 2.6% of bulk chemicals downward. The top three industrial activities represent 62.3% of emissions from industrial installations in 2020.

In 2020, 9,762 installations are involved in the ETS (-2.7% of 2019 entities), just below the 2005 entities (9,873). In 2013, with the ETS revision for phase 3, the number of installations jumped to 10,774 (+5.9% of 2012 entities). At the end of the 3rd phase the number of installations decreased of 9.4% compared to 2013. The average emissions by installations (intensity) decreased by 32% in 2020 since 2005 and by 21.6% since 2013. Such intensity reduction is mainly due to the combustion of fuels installations. The average emission intensities recorded in 2020 for Germany, Poland, the Netherlands, and Czechia are above the average of all countries (152.8 $ktCO_2eq$), from 32% more in Germany to 99.9% more in Poland. All countries' average intensity is shrinking, although Poland and Czechia show increasing trends since 2013. The average intensity in 2020 was 146 $ktCO_2eq$ in industrial installations and 134.5 $ktCO_2eq$ in combustion of fuels installations. Industrial sectors with highest intensity are refining of mineral oil and production of ammonia (936 $ktCO_2eq$ and 808.3 $ktCO_2eq$ respectively), followed by production of coke (570.4 $ktCO_2eq$), cement clinker (521.5 $ktCO_2eq$), and the production of pig iron or steel sector (519.9 $ktCO_2eq$). The remaining sectors range from 11.8 $ktCO_2eq$ for production of glyoxal and glyoxylic acid to 315.2 $ktCO_2eq$ for production of soda ash and sodium bicarbonate.

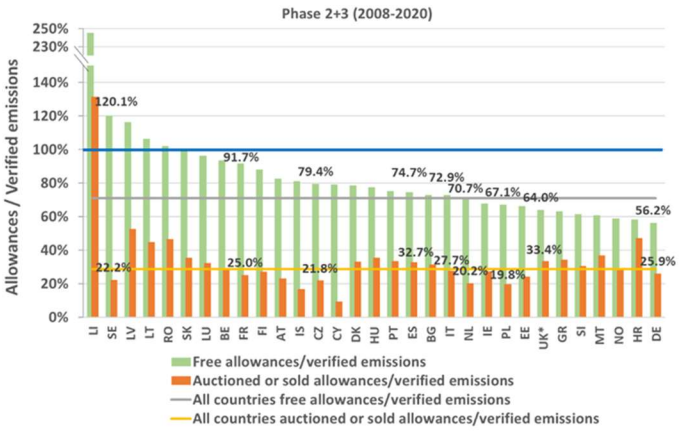
The surplus/deficit of free allowances has been analysed carrying out the ratio between allowances and verified emissions. Ratios higher than 1 represent surplus of free allowances, recorded mainly from 2009 as a consequence of the economic crisis which reduced production activities. Since 2013, with the start of phase 3, the ratio dropped below 1. In particular, the trend of freely allocated allowances in the 3rd phase shows a gradual decrease from 53.1% to 44.5% compared to the verified emissions in the period 2013-2018, followed by an upward trend in the next years: 47.1% in 2019 and 49.3% in 2020. The free allowances surplus has been recorded for industrial installations which show values just below 1 only from 2017 (0.99) to 2019 (0.98). For all other years the ratios is much higher than 1 and in the phase 3, from 10.8% more in 2013 to 2.6% in 2017 and 2.2% in 2020.

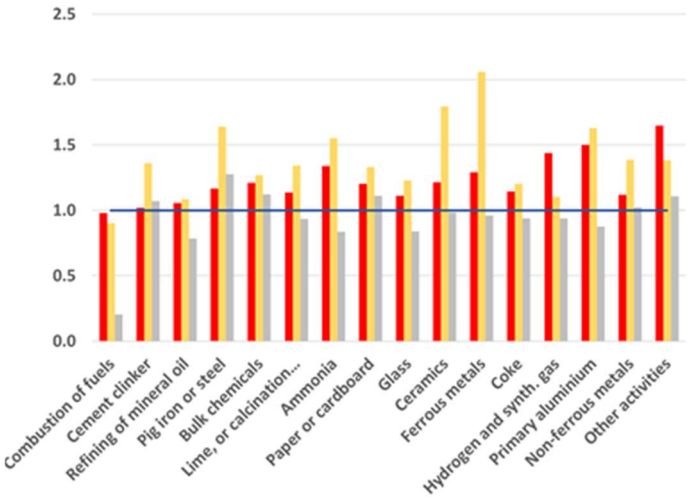




The percentage of freely allocated allowances compared to total allowances by country show that, compared to 47.8% for the whole system in 2020, some countries, as France, the Netherlands, Austria, and Belgium, recorded free allowances share close to 70%. Sweden recorded the highest share of 79%. The percentage of freely allocated allowances compared to verified emissions from 2008 to 2020 shows that during the 2nd phase (2008-2012), the great majority of countries had relevant surpluses of free allocation with few exceptions, as Germany and the United Kingdom among the biggest countries. During the 3rd phase (2013-2020) only Sweden and Lichtenstein had significant surpluses.

The ratios between cumulative free allowances and cumulative verified emissions since 2008 for each country show that at the end of phase 3 the only countries with surplus of free allowances are Liechtenstein (2.5 times more free allowances than verified emissions), Sweden (surplus of 19.4%), Latvia (surplus of 16.2%), Lithuania (surplus of 5.1%), and Romania (surplus of 2%). No one of the biggest countries show surplus of free allowances, although there is a wide range of ratios from 0.57 in Germany to 0.92 in France.

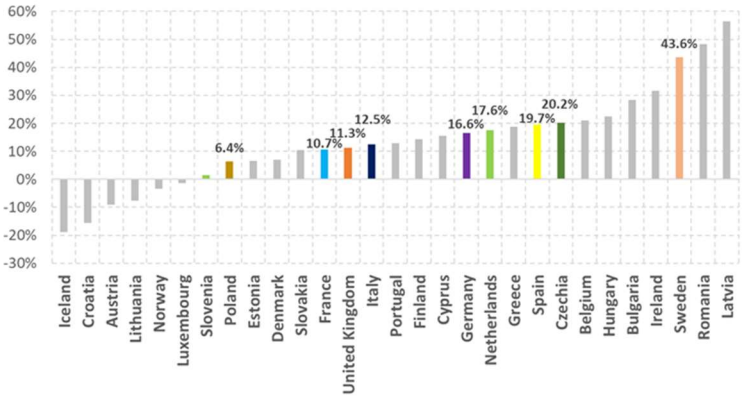




The ratio by sector shows that many sectors recorded surplus of free allowances in 2nd and 3rd phases. Even in the 3rd phase relevant activity sectors such as pig iron or steel, cement clinker, bulk chemical, paper or cardboard, and non-ferrous metals recorded surpluses from 2.1% to 27.5%.

The ratio between cumulative free allowances and cumulative verified emissions since 2008 allows to assess the cumulated deficit/surplus of allowances at the end of the 3rd phase. The free allowances in Germany are 56.2% of the emissions. The percentage for Italy is 72.9%. At the other end there are countries, as Sweden, with percentages greater than 100%, in other words with more free allowances than the verified emissions. The percentage of free allowances may be more usefully read in terms of deficit or surplus of allowances, i.e. verified emissions to be offset by allowances available on market (deficits) or greater availability of free allowances than verified emissions (surplus). Countries with negative percentages have a deficit of free allowances, while countries with positive percentages have surplus.

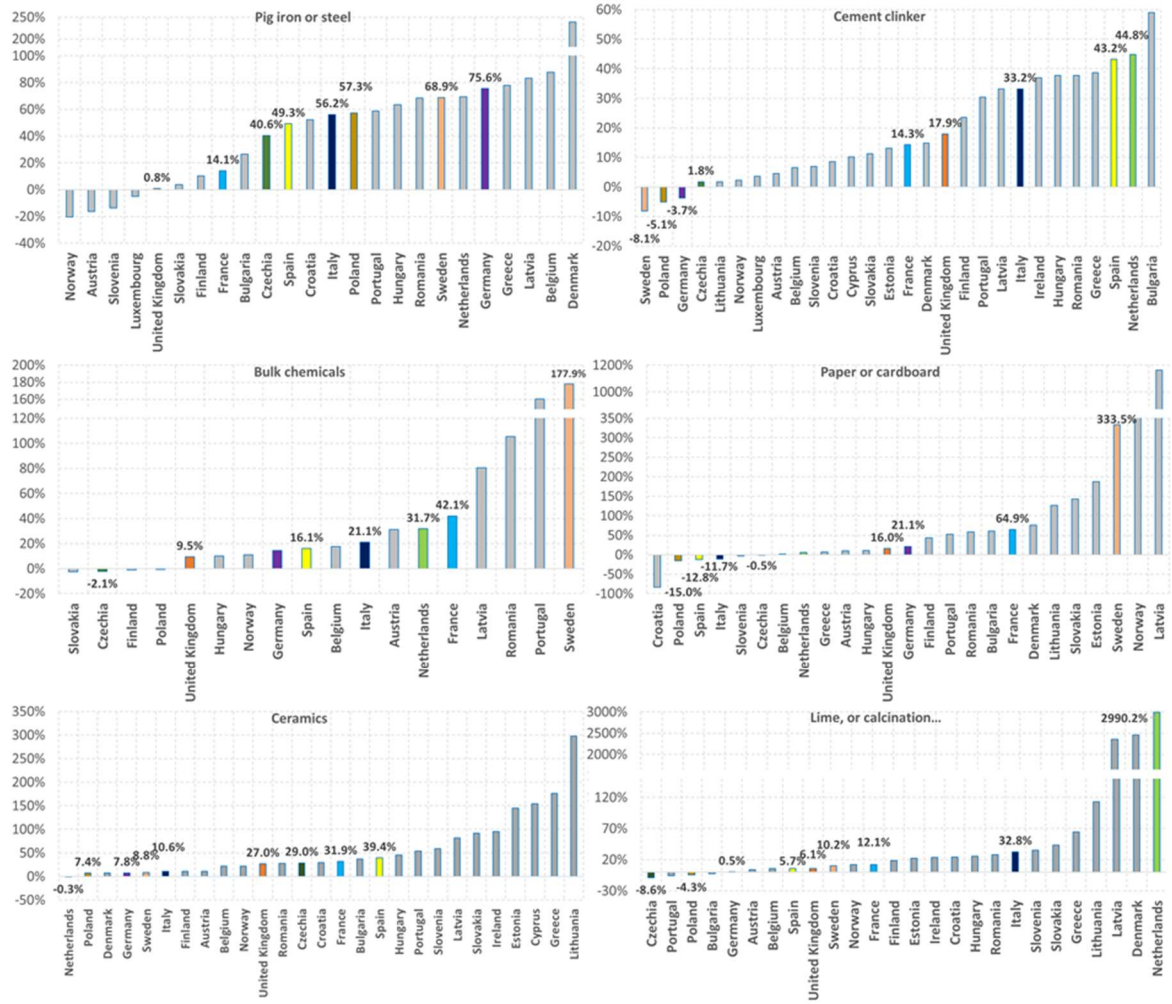
Considering only industrial installations, whose ratio of free allowances to verified emissions at overall level is close to 1 in the 3rd phase but much higher than 1 in the previous phase, it is possible noting a wide range of deficit/surplus between countries and, among the examined ones, surpluses range from 6.4% in Poland and 43.6% in Sweden.



Combustion of fuels installations, considering that since 2013 do not have freely allocated allowances for the electricity production, registered deficits that range from -14.8% in Sweden to -63.9% in Germany.

The sectoral analysis shows that the majority of industrial activity sectors have surplus of free allowances in the period 2008-2020, from 1.6% for the carbon black sector to 703.4% for the production of adipic acid. Cumulative emissions from sectors with free allowance surpluses account for 69.8% of

industrial emissions. The surplus concerns sectors with high share of emissions, such as the cement clinker sector and pig iron or steel sector. Moreover, it should be pointed out that surpluses of free allowances have been recorded also for sectors entered in ETS at the 3rd phase. Each country has its own sectors with surplus, although some sectors, such as cement clinker and bulk chemicals, have surpluses in almost all the examined countries, or sector as pig iron or steel with surplus in all the examined countries, although of different sizes.



Free allowances surplus enters in the carbon market to offset deficit, mainly by combustion of fuels installations. A summary for the total allocated allowances, therefore also considering the allowances auctioned or sold, shows that at overall level the ETS has a substantial balance between allowances and emissions with a slight deficit of allowances, although at sectoral level significant surplus of freely allocated allowances has been recorded for relevant industrial sectors. Reducing such surplus is a key factor in achieving the GHG emissions reduction target in the ETS. The ETS revision for phase 4 should consider the actual risk of carbon leakage without introducing market distortion with excessive sector surplus of free allowances.

The aviation joined the EU ETS on 1 January 2012. In 2012 the sector emissions accounted for about 4% of total ETS emissions. The aviation share of emissions, although quite variable, ranges from the highest 4.5% in 2019 to the lowest 1.8% in 2020. Just after the first year the sector showed a sharp fall of emissions, from 84.0 $MtCO_2$ to 53.5 $MtCO_2$ in 2013. Since the beginning of the 3rd phase the sector emissions increased up to 2019 (+27.5% compared to 2013). The sector has been heavily affected by lockdown measures to contain the diffusion of SARS-CoV-2 pandemic in 2020 and emissions for this year fell by 63.5% compared to the previous year. The emissions share by country has changed relevantly from 2012 to 2020. The share of the biggest countries decreased from 70.7% to 55.8%.

As for the ratio between allowances and verified emissions, in 2012 the availability of free allowances was more than double the verified emissions. Since 2013 the free allowances share on verified emissions decreased steadily from 60.1% to 44.3% in 2019. In 2020 free allowances are 21.1% more than verified emissions. The cumulative ratios since 2012 show that the biggest countries have the higher percentage of free allowances compared to verified emissions, higher than the average for all countries. The only countries with surplus of free allowances are Cyprus and the United Kingdom.

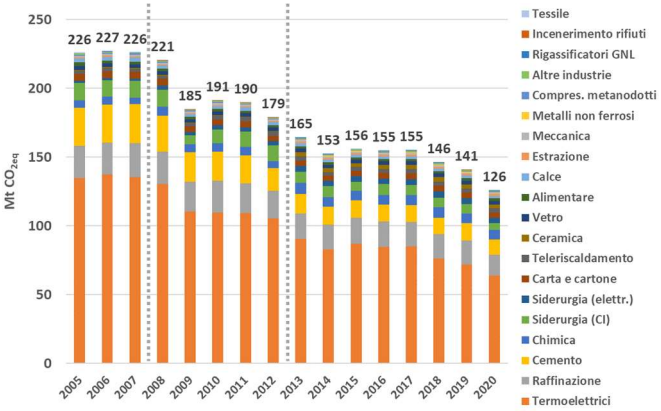
SOMMARIO (Italiano)

Il sistema di scambio di quote di emissione dell'UE (EU-ETS) è una delle principali politiche dell'Unione Europea per contrastare i cambiamenti climatici ed è uno strumento essenziale per ridurre in maniera economicamente efficiente le emissioni di gas a effetto serra. Il sistema comprende le emissioni di circa 10.000 impianti e delle compagnie aeree e interessa circa il 40% delle emissioni serra dell'UE. I settori ETS hanno l'obiettivo di riduzione delle emissioni a livello europeo del 21% nel 2020 rispetto ai livelli del 2005. Le emissioni dagli impianti stazionari si sono ridotte del 42,8% dal 2005 al 2020, considerando anche le emissioni dall'aviazione la riduzione è stata del 41,7%. Per raggiungere i nuovi obiettivi del 2030 (riduzione delle emissioni totali di gas serra di almeno 55% rispetto al 1990), il sistema ETS è stato profondamente riformato ed esteso ai settori del trasporto navale, stradale e al settore civile. La riduzione attesa delle emissioni del nuovo ETS è del 61% rispetto al 2005 (43% per il trasporto su strada e gli edifici), mentre la riduzione per i settori *Effort Sharing*, non interessati dal sistema ETS, sarà del 40% rispetto al 2005.

Il raggiungimento degli obiettivi di riduzione del sistema dipende dall'equilibrio di mercato tra domanda di emissioni e offerta di quote allocate. Il rapporto tra quote allocate in circolazione, soprattutto allocate gratuitamente, ed emissioni verificate è un parametro chiave per il corretto funzionamento del sistema. La fine della terza fase ETS consente di elaborare un bilancio finale per le emissioni di gas serra e le quote allocate a partire dal 2008 al fine di valutare eventuali *surplus* o *deficit* di quote allocate in Italia e nei principali paesi Europei.

Dati nazionali

Le emissioni dal sistema ETS rappresentano mediamente il 37% delle emissioni di gas serra nazionali dal 2005. Considerando anche le emissioni stimate per riflettere l'attuale legislazione dopo la riforma dell'ETS dal 2013, la quota di emissioni ETS nel 2005 è stata del 42%. Dal 2005 la quota è diminuita fino a circa 33% nel 2020, secondo stime provvisorie delle emissioni di gas serra nazionali.

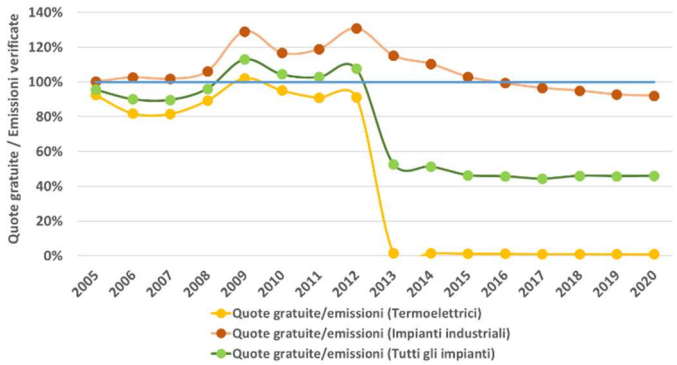


Gli impianti di produzione elettrica rappresentano il settore predominante con percentuali di emissioni superiori al 50% delle emissioni totali dai settori ETS nel 2020. Il settore è seguito dalla raffinazione di prodotti petroliferi (12% delle emissioni) e dal settore cementiero (9%). Le emissioni dal settore della chimica rappresentano circa il 4%. I quattro settori menzionati rappresentano più del 75% delle emissioni totali da ETS nel 2020. La quota di emissione dagli stessi settori è diminuita da 84,7% nel 2005 a 76,9% nel 2020. Le percentuali di riduzione delle emissioni sono molto eterogenee tra i diversi settori. Considerando le emissioni stimate per il 2005 con l'attuale legislazione la riduzione delle emissioni nel 2020 è stata del 49,1%.

Le emissioni dagli impianti industriali sono state 62,2 $MtCO_2eq$ nel 2020, con un incremento della quota relativa negli anni più recenti, da 45% delle emissioni ETS nel 2013 a 49,4% nel 2020. Dal 2005 la quota di emissioni da impianti termoelettrici è diminuita da 59,5% to 50,6%.

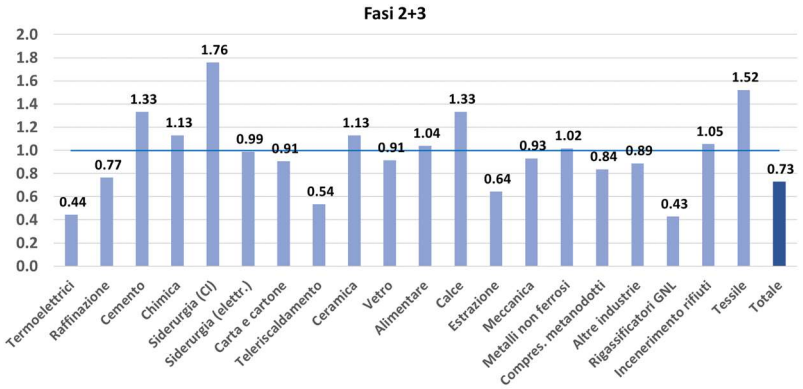
La maggior parte delle emissioni ETS sono dovute a un numero relativamente piccolo di impianti appartenenti a settori con le più alte intensità emissive per impianto, come impianti termoelettrici, raffinerie, cementifici e acciaierie a ciclo integrato. Le emissioni sono maggiormente 'concentrate' nel 2005 rispetto al 2020. Nel 2005 il 95% delle emissioni era dovuto al 31,4% degli impianti (296), mentre nel 2020, la soglia è raggiunta dal 41,9% degli impianti (408). Le emissioni medie per impianto

(intensità emissiva) diminuisce sensibilmente da 239,9±886,4 kt CO_2eq nel 2005 a 129,4±414,9 kt CO_2eq nel 2020. L'intensità degli impianti termoelettrici diminuisce da 981,5±1.841,2 kt CO_2eq a 490,8±744,8 kt CO_2eq dal 2005 al 2020, mentre per gli impianti industriali è diminuita da 113,7±486,4 kt CO_2eq a 73,7±300,9 kt CO_2eq.

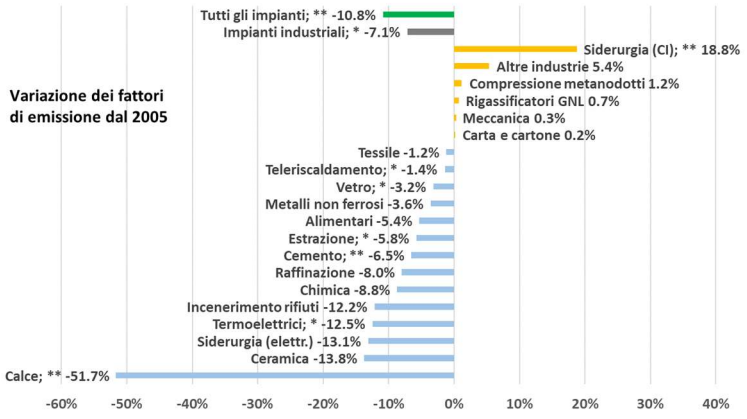


Il rapporto tra quote allocate gratuitamente e emissioni verificate consente di valutare eventuali *surplus* o *deficit* di quote. Dal 2009 al 2012 si registra un notevole *surplus* di quote gratuite soprattutto a carico dei settori industriali. Il *surplus* è principalmente dovuto agli effetti della crisi economica che ha ridotto in quegli anni le attività produttive.

I rapporti per settore tra quote gratuite cumulate e emissioni cumulate dal 2008 mettono in evidenza i settori con *surplus* di quote gratuite, da 1,8% nel settore dei metalli non-ferrosi a 75,8% nelle acciaierie a ciclo integrato. L'intero sistema ETS ha fatto registrare un *deficit* di quote gratuite del 27,1% più che compensato dalla domanda di quote dal settore della produzione elettrica.



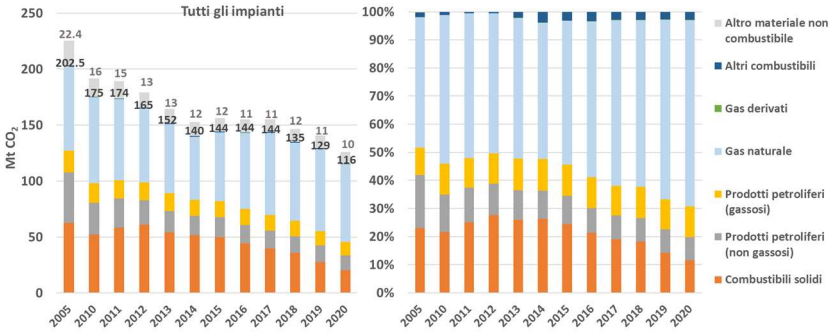
I consumi di energia negli impianti ETS, da combustibili fossili e bioenergie, ammontano a 69,5 Mtep nel 2005, 36,7% del consumo interno lordo nazionale. Nel 2020 i consumi sono scesi a 44,5 Mtep, 31,3% della stima provvisoria di consumo interno lordo. Dal 2005 al 2020 i consumi di energia si sono ridotti del 36%, mentre le emissioni di gas serra sono diminuite del 44,2%. In particolare le emissioni da consumo di combustibili, che rappresentano quasi il 92% delle emissioni ETS, sono diminuite del 42,9%.



I fattori di emissione per settore, dati dal rapporto tra emissioni e contenuto energetico dei combustibili, diminuiscono nel periodo 2005-2020 sia negli impianti termoelettrici che negli impianti industriali. Solo alcuni settori industriali fanno registrare un incremento dei fattori di emissione che è statisticamente significativo per le acciaierie a ciclo integrato. (+18,8% nel 2020 rispetto al 2005). I settori con un incremento dei fattori di emissione rappresentano l'8,7% delle emissioni ETS nel 2020.

La diminuzione dei fattori di emissione è principalmente dovuta alla diminuzione dei consumi di combustibili con elevato contenuto di carbonio come combustibili solidi e da prodotti petroliferi non gassosi (da 42,1% a 19,9% dal 2005 al 2020) e al corrispondente incremento della quota di energia da gas naturale (da 46,6% a 63,3%). Il settore elettrico ha un ruolo importante nella variazione del mix energetico, la quota di energia da gas naturale è aumentata da 54.2% nel 2005 a 79.2% nel 2020, mentre

la quota di combustibili solidi e prodotti petroliferi non gassosi è diminuita da 38,5% a 14,3%. Anche nei settori industriali si registra un notevole incremento dei consumi di energia da gas naturale (da 32,8% a 50,8%) nel periodo 2005-2020, e conseguente diminuzione da combustibili solidi e gas derivati (da 19,2% to 7,9%), e da prodotti petroliferi non gassosi (da 23,5% a 16,9%).



Le emissioni per combustibile e per settore forniscono utili indicazioni sul raggiungimento degli obiettivi di riduzione delle emissioni nei settori ETS al 2030. Secondo le ultime proiezioni delle emissioni nazionali inviate da ISPRA alla Commissione Europea nel marzo del 2021, elaborate prima delle proposte di riforma del '*fit for 55*' ma che considerano gli effetti del Covid-19, le emissioni ETS nel 2030 saranno 123,0 $MtCO_2$ nello scenario con le attuali misure (WEM; -50,3% rispetto al 2005) e 95,7 $MtCO_2$ per lo scenario con misure addizionali (WAM; -61,4% rispetto al 2005). L'attuale revisione del sistema ETS porterà a una riduzione delle emissioni dei settori ETS a livello europeo del 61% nel 2030 rispetto al 2005. Applicando tale riduzione agli attuali settori ETS in Italia le emissioni nel 2030 dovrebbero essere di circa 97 $MtCO_2$, circa 26 $MtCO_2$ meno delle proiezioni dello scenario WEM ma superiori di circa 1 $MtCO_2$ rispetto allo scenario WAM. Tali numeri mostrano chiaramente che l'Italia dovrà adottare misure addizionali previste nel Piano Nazionale Integrato per l'Energia e il Clima per raggiungere i nuovi obiettivi di riduzione e che il settore elettrico avrà un ruolo cruciale con l'uscita dal carbone entro il 2025 e l'incremento dell'elettricità da fonti rinnovabili fino al 55% nel 2030 dall'attuale 40%.

Il mix di combustibili non è il solo fattore determinante l'andamento delle emissioni. Un ruolo importante è anche dovuto al contenuto specifico di carbonio dei singoli combustibili che in diversi casi, come per gas naturale, gas derivati e prodotti petroliferi gassosi, ha fatto registrare significative riduzioni dal 2013.

Ogni settore industriale ha uno specifico mix di combustibili in relazione all'assetto tecnologico del settore alle esigenze di produzione. Alcuni settori consumano prevalentemente una o poche tipologie di combustibili, mentre altri hanno una maggiore omogeneità di consumi delle varie tipologie. Nei settori di produzione di cemento o calce il consumo di combustibili diversi da quelli fossili, rifiuti e bioenergie, è notevolmente aumentato. Nei cementifici si registra un costante incremento dei consumi di energia da tali fonti che nel 2020 rappresentano il 21,0% della domanda energetica. Nel 2020 il settore della calce soddisfa il 49,4% della domanda energetica con biomassa solida, mentre il settore dell'industria alimentare soddisfa il 15,7% della domanda energetica con rifiuti e biomassa.

La distribuzione degli impianti nelle diverse regioni mostra una più elevata concentrazione di impianti nelle regioni del Nord, soprattutto Lombardia e Emilia Romagna. D'altra parte le emissioni nelle regioni del Sud, come Puglia e Sicilia, mostrano rilevanti quote nonostante il minor numero di impianti. Le regioni del Sud hanno maggiori emissioni da impianti termoelettrici. Le regioni del Nord hanno il più alto numero di impianti industriali nonostante presentino emissioni comparabili a quelle registrate nelle regioni del Sud e nelle Isole (23,4% *vs* 20,5%). A livello nazionale dal 2005 al 2020 è stato registrato un incremento del 4,8% del numero di impianti industriali, mentre le emissioni sono diminuite del 32%.

L'intensità emissiva per impianto è diminuita del 46,1% a livello nazionale, con riduzioni più elevate nel Nord-Est e nel Centro. Nelle regioni del Sud e nelle Isole si registrano le intensità emissive più elevate con valori da 1,8 a 3,5 volte la media nazionale del 2020. In queste regioni si registrano le più alte intensità emissive per gli impianti termoelettrici e industriali alimentati da combustibili solidi, soprattutto in Puglia e Sicilia.

Negli impianti industriali si registra in tutte le macroaree una riduzione piuttosto marcata delle emissioni da combustibili solidi e prodotti petroliferi, tuttavia nelle regioni del Sud si registra una elevata quota di emissioni da combustibili solidi e nelle Isole una quota significativa di emissioni da prodotti petroliferi a causa della presenza del polo siderurgico in Puglia e delle principali raffinerie in Sicilia e Sardegna. Le emissioni da prodotti petroliferi non gassosi si riducono in tutte le regioni con poche eccezioni. Le riduzioni più elevate si registrano negli impianti termoelettrici, con diminuzioni rispetto al 2005 di quasi il 100% in molte regioni e 96% a livello nazionale. La riduzione negli impianti industriali è del 43,4% (68.4% al Centro e 75,2% al Sud).

Le cinque province con più elevate emissioni sono Taranto, Siracusa, Brindisi, Cagliari, e Roma con emissioni da 9,3 a 5,7 $MtCO_2eq$ nel 2020, pari al 29,1% delle emissioni totali da impianti ETS.

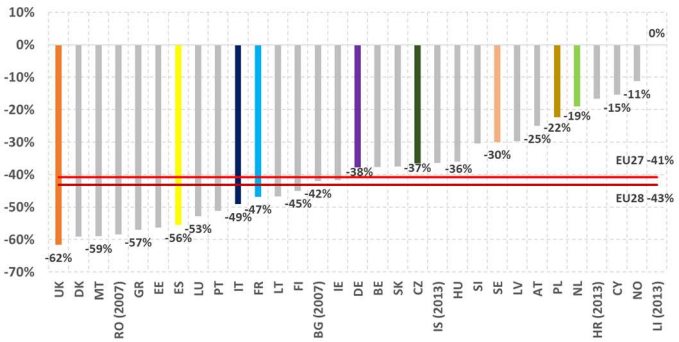
Dati Europei

Il sistema EU ETS coinvolge 31 paesi Europei, i 28 Stati Membri dell'Unione (l'uscita del Regno Unito dall'Unione Europea è avvenuta il 31 dicembre 2020) più Norvegia, Islanda e Lichtenstein.

Le emissioni totali da ETS nel 2020 sono state 1.355 $MtCO_2eq$ (-42,8% rispetto al 2005). La riduzione dal 2005 per EU28 e EU27 è stata rispettivamente del 43,2% e 40,7%. La quota di emissioni ETS rispetto alle emissioni totali di gas serra in EU28 è diminuita da 44,7% nel 2005 a 37% nel 2019. Nel 2020 tutte le attività economiche sono state influenzate dalle misure di chiusura per contenere la pandemia di SARS-CoV-2.

I primi quattro Stati in termini di emissioni ETS (Germania, Polonia, Italia e Regno Unito) rappresentano più del 50% delle emissioni ETS totali (53,1% nel 2005 e 53,4% nel 2020). La quota totale non è cambiata dal 2005, benché tale costanza sia il risultato di un incremento della quota di Germania e Polonia e una diminuzione della quota di Italia e Regno Unito. I primi otto Stati sono responsabili di più del 75% delle emissioni ETS (75,5% nel 2020). Considerando anche la Svezia la quota sale a 76,7%.

Gli Stati hanno fatto registrare un ampio intervallo di riduzioni delle emissioni rispetto al loro anno di ingresso in ETS. Le riduzioni nei principali paesi vanno da 19% nei Paesi Bassi a 61.6% nel Regno Unito. Dopo il Regno Unito le riduzioni più elevate, sotto la percentuale media per tutti i paesi (42,8%), sono state registrate per Spagna (55,5%), Italia (49,1%) e Francia (46,8%).



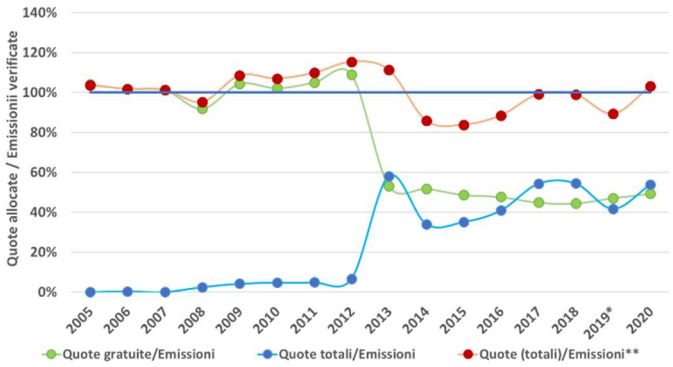
Tra gli Stati più grandi il Regno Unito, Spagna e Italia hanno i tassi di riduzione media annuale più elevati, da 4,4% a 6,2%. All'estremo opposto i Paesi Bassi hanno un tasso di riduzione medio annuale di 1,4%.

La riduzione delle emissioni è principalmente dovuta agli impianti di combustione le cui emissioni diminuiscono del 43,1% dal 2005. Gli impianti industriali non fanno registrare un chiaro andamento di riduzione, eccetto dal 2009 al 2012 quando la crisi economica ha rallentato le attività produttive in molti Stati. Dal 2005 al 2020 gli impianti industriali hanno ridotto le emissioni del 6,5%. Va comunque considerato il ruolo delle misure per contenere la pandemia da SARS-CoV-2 nel 2020. Dal 2013 solo pochi settori hanno fatto registrare diminuzioni delle emissioni statisticamente significative: impianti di combustione, raffinazione, siderurgico e produzione di coke. Tra i principali Stati i soli con riduzioni statisticamente significative delle emissioni da impianti industriali dal 2013 sono Italia, Regno Unito e Francia.

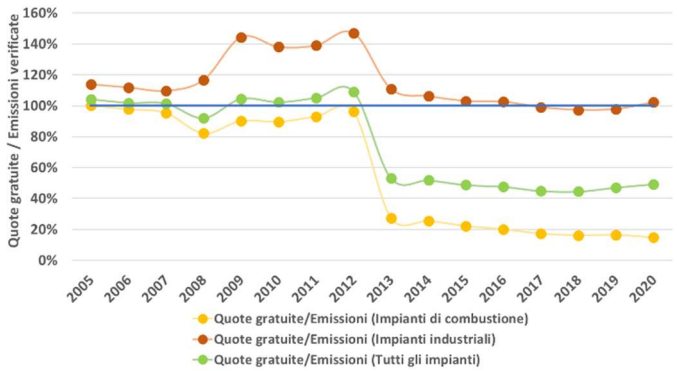
Gli impianti di combustione sono responsabili della maggior parte delle emissioni ETS: 60,6% nel 2020, principalmente dovute agli impianti termoelettrici. Gli impianti industriali dei settori del cemento, raffinazione, siderurgico seguono contribuendo rispettivamente al 8,4%, 8,4% e 7,8% delle emissioni

ETS. Gli altri settori hanno percentuali più basse, a partire da 2,6% dell'industria chimica. I primi tre settori industriali rappresentano il 62,3% delle emissioni industriali nel 2020.

Nel 2020 gli impianti coinvolti in ETS sono stati 9.762 (-2.7% rispetto al 2019), appena inferiori al dato del 2005 (9.873). Nel 2013, con la revisione del sistema per la fase 3, il numero di impianti è salito a 10.774 (+5.9% rispetto al 2012). Alla fine della terza fase il numero di impianti è diminuito del 9,4% rispetto al 2013. Le emissioni medie per impianto (intensità) sono diminuite del 32% dal 2005 e del 21,6% dal 2013. Tale riduzione è principalmente dovuta agli impianti di combustione. Le intensità medie in Germania, Polonia, Paesi Bassi e Repubblica Ceca nel 2020 sono superiori alla media registrata per tutti gli Stati (152,8 $ktCO_2eq$), dal 32% in più in Germania al 99,9% in Polonia. L'intensità media per tutti gli Stati è in forte diminuzione nonostante Polonia e Repubblica Ceca abbiano andamenti crescenti dal 2013. L'intensità media nel 2020 è stata 146 $ktCO_2eq$ degli impianti industriali e 134,5 $ktCO_2eq$ negli impianti di combustione. I settori industriali con le più alte emissioni per impianto sono la raffinazione e gli impianti di produzione dell'ammoniaca (936 $ktCO_2eq$ e 808,3 $ktCO_2eq$ rispettivamente), seguiti dagli impianti di produzione del coke (570,4 $ktCO_2eq$), dai cementifici (521,5 $ktCO_2eq$) e dagli impianti del settore siderurgico (519,9 $ktCO_2eq$). I restanti settori hanno intensità medie che vanno da 11,8 $ktCO_2eq$ per la produzione di gliossalato e acido gliossalico a 315,2 $ktCO_2eq$ per la produzione di soda e bicarbonato di sodio.

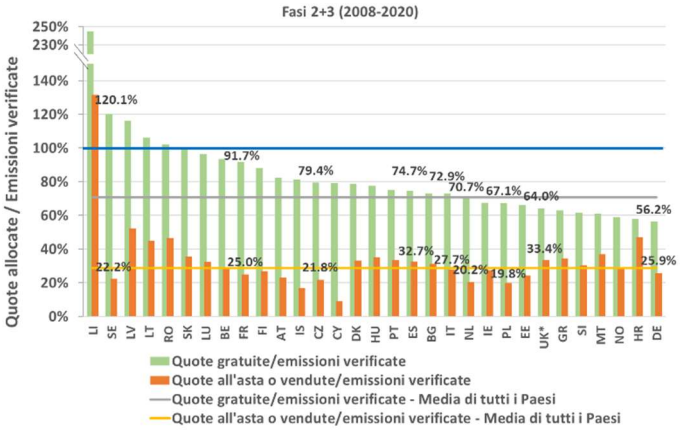


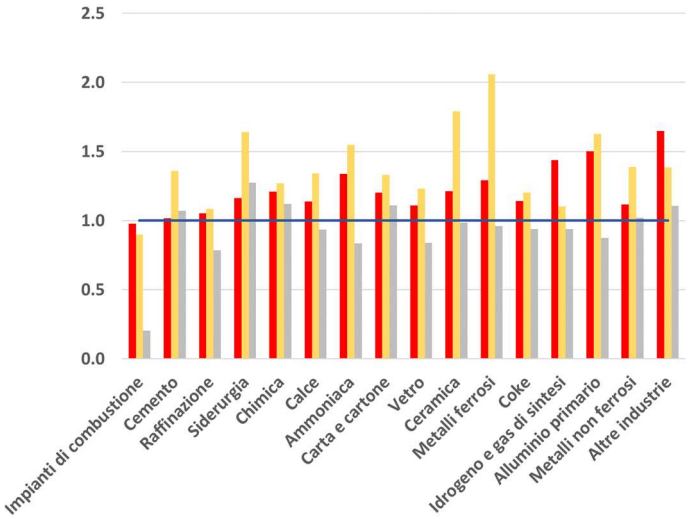
Il *surplus/deficit* di quote è stato analizzato eseguendo il rapporto tra quote assegnate gratuitamente e emissioni verificate. Rapporti maggiori di 1 rappresentano *surplus* di quote, registrati dal 2009 in conseguenza della contrazione delle attività produttive in seguito alla crisi economica. Dal 2013, con l'inizio della fase 3, il rapporto è inferiore a 1. In particolare, le quote allocate gratuitamente nella terza fase mostrano una graduale diminuzione, da 53,1% a 44,5% delle emissioni verificate nel periodo 2013-2018, seguito da un aumento negli anni successivi: 47,1% nel 2019 e 49,3% nel 2020. Il *surplus* di quote gratuite è stato registrato nei settori industriali, che hanno rapporti inferiori a 1 solo dal 2017 (0,99) al 2019 (0,98). Negli altri anni il rapporto è molto più elevato di 1 e nella fase 3 più elevato da 10,8% nel 2013 a 2,6% nel 2017 e 2.2% nel 2020.



La percentuale per Stato di quote allocate gratuitamente rispetto alle quote totali mostra che, a fronte del 47,8% dell'intero sistema ETS nel 2020, alcuni Stati, come Francia, Paesi Bassi, Austria e Belgio, hanno percentuali di quote gratuite vicine al 70%. La Svezia ha il valore più alto con 79%. La percentuale di quote gratuite rispetto alle emissioni verificate mostra che dal 2008 al 2012 la maggior parte degli Stati ha rilevanti *surplus* di quote gratuite con poche eccezioni, come Germania e Regno Unito tra i paesi più grandi. Dal 2013 al 2020 si registrano *surplus* solo in Svezia e Lichtenstein.

Il rapporto tra quote gratuite cumulate e emissioni cumulate dal 2008 per ogni Stato mostra che i soli Stati con *surplus* di quote gratuite alla fine della 3ª fase sono Liechtenstein (2,5 volte più quote gratuite delle emissioni), Svezia (*surplus* del 19,4%), Lettonia (*surplus* del 16,2%), Lituania (*surplus* del 5,1%), e Romania (*surplus* del 2%). Nessuno dei paesi più grandi fa registrare *surplus* di quote gratuite, benché ci sia un ampio intervallo dei rapporti da 0,57 in Germania a 0,92 in Francia.

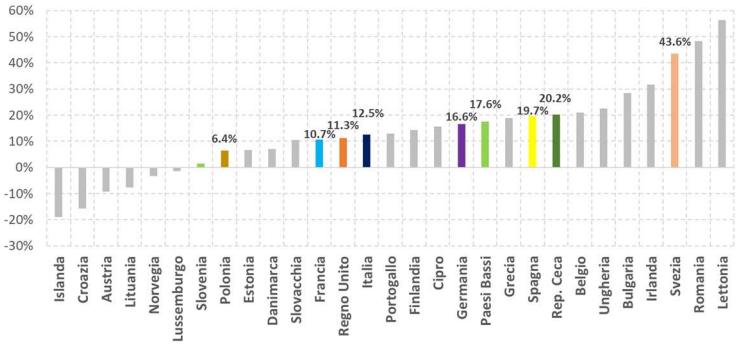




Il rapporto quote gratuite e emissioni per settore mostra che molti settori industriali hanno *surplus* di quote gratuite sia nella 2ª che nella 3ª fase. Importanti settori come siderurgico, cementiero, industria chimica, cartaria e dei metalli non ferrosi hanno *surplus* anche nella 3ª fase da 2,1% a 27,5%.

Il rapporto tra quote gratuite cumulate e emissioni cumulate dal 2008 consente di valutare i *deficit/surplus* di quote cumulati fino alla fine della 3ª fase. Le quote gratuite in Germania sono il 56,2% delle emissioni. La percentuale per l'Italia è 72,9%. All'altro estremo ci sono Stati, come la Svezia, con percentuali più alte del 100%, ovvero con più quote gratuite delle emissioni verificate. La percentuale di quote gratuite rispetto alle emissioni può essere letta in termini di *deficit* o *surplus* di quote, ovvero emissioni verificate da compensare con quote disponibili sul mercato (*deficit*) o maggiore disponibilità di quote gratuite rispetto alle emissioni verificate (*surplus*). Stati con percentuali negative hanno *deficit* di quote gratuite, mentre Stati con percentuali positive hanno *surplus*.

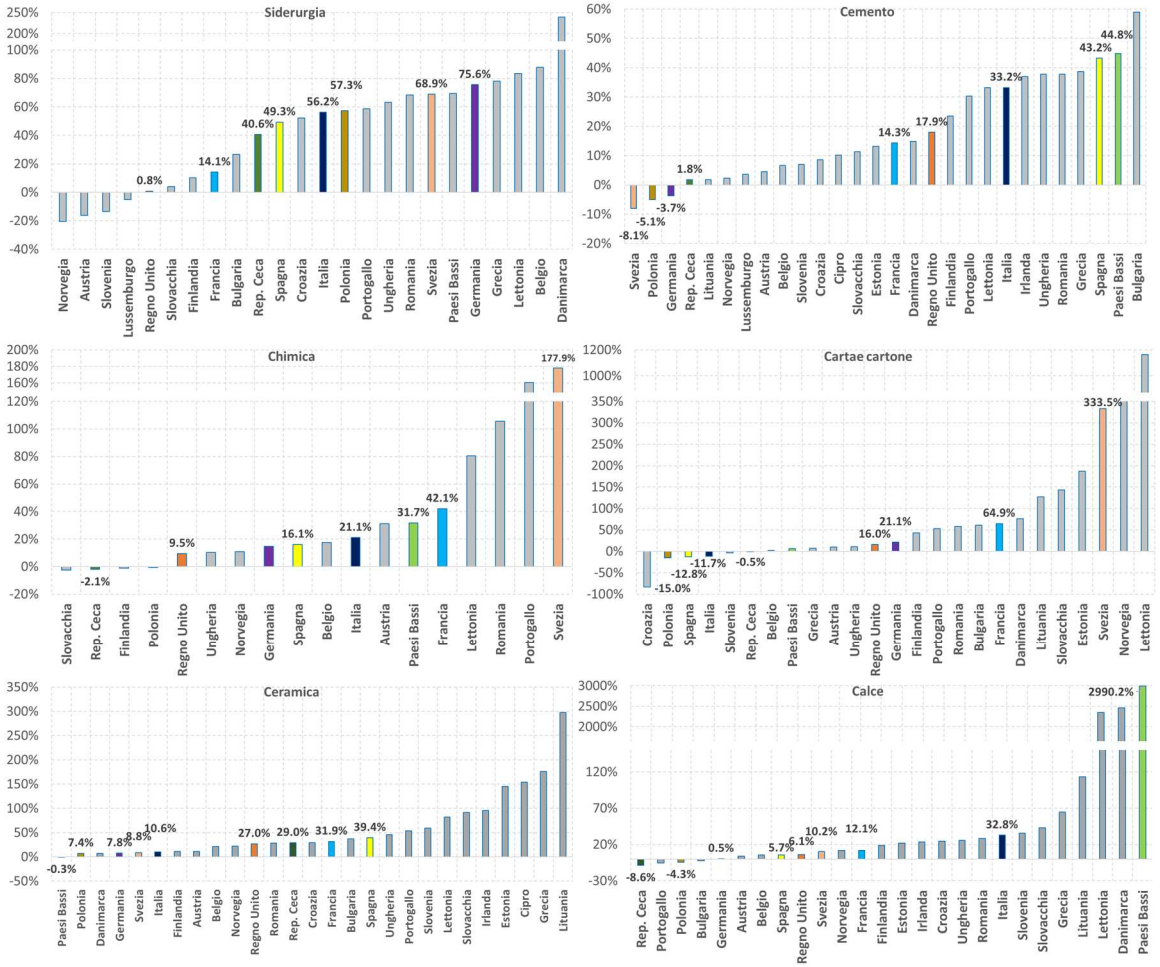
Considerando solo gli impianti industriali, il cui rapporto tra quote gratuite e emissioni è vicino all'unità nella 3ª fase ma molto più alto di 1 nella 2ª, si notano un ampio intervallo di *deficit* e *surplus* tra i diversi Stati e, tra quelli esaminati, i *surplus* vanno da 6,4% in Polonia a 43,6% in Svezia.



Gli impianti di combustione, considerando che dal 2013 non sono previste quote gratuite per la produzione di elettricità, fanno registrare *deficit* che vanno da -14,8% in Svezia a -63,9% in Germania.

L'analisi a livello settoriale mostra che la maggioranza dei settori industriali hanno *surplus* di quote gratuite cumulate nel periodo 2008-2020, da 1,6% per il settore di produzione del *carbon black* a 703,4% per la produzione di acido adipico. Le emissioni cumulative nei settori con *surplus* rappresentano il 69,8% delle emissioni cumulative da impianti industriali. Il *surplus* riguarda settori con elevate emissioni quali il cementiero e il siderurgico. Inoltre, tale *surplus* riguarda anche settori entrati in ETS

nella 3ª fase. Ogni Stato presenta specifici settori con *surplus*, sebbene alcuni settori, come industria del cemento, industria chimica e siderurgico, abbiano *surplus* in quasi tutti o in tutti gli Stati esaminati.



Il *surplus* di quote gratuite compensa i *deficit* registrati principalmente negli impianti di combustione. Considerando anche le quote all'asta o vendute il sistema ETS mostra un sostanziale equilibrio tra quote totali e emissioni verificate con un leggero *deficit* di quote totali, nonostante siano stati individuati rilevanti *surplus* di quote gratuite in importanti settori industriali. La riduzione di tali *surplus* è una misura chiave per raggiungere gli obiettivi di riduzione delle emissioni ETS di gas serra. La revisione del sistema ETS per la 4ª fase dovrebbe valutare il reale rischio di *carbon leakage* dei settori industriali e la relativa assegnazione di quote gratuite senza introdurre distorsioni di mercato con eccessivi *surplus* di quote gratuite.

Il settore dell'aviazione è entrato in EU ETS il 1 gennaio 2012. Le emissioni del settore nel 2012 rappresentavano circa il 4% delle emissioni totali da ETS. La quota di emissioni dall'aviazione è oscillata dal più alto 4,5% nel 2019 al più basso 1,8% nel 2020. Già dal 2013 il settore ha mostrato una rapida diminuzione delle emissioni, da 84,0 $MtCO_2$ nel 2012 a 53,5 $MtCO_2$ nel 2013. Dall'inizio della 3ª fase le emissioni sono aumentate del 27,7% fino al 2019. Il settore è stato pesantemente colpito dalle misure di *lockdown* per contenere la diffusione della pandemia da SARS-CoV-2 e le emissioni del 2020 fanno registrare una riduzione del 63.5% rispetto all'anno precedente. La quota di emissioni per Stato è cambiata notevolmente dal 2012 al 2020. La quota dei paesi più grandi diminuisce da 70,7% a 55,8%.

Nel 2012 la disponibilità di quote gratuite nel settore è stata più del doppio delle emissioni. Dal 2013 la disponibilità di quote gratuite è diminuita da 60,1% a 44,3% nel 2019. Nel 2020 le quote gratuite sono il 21,1% in più delle emissioni. Il rapporto tra quote e emissioni cumulative dal 2012 mostra che gli Stati più grandi hanno le percentuali più elevate di quote gratuite rispetto alle emissioni, con valori più elevati della media di tutti gli Stati. I soli Stati con *surplus* di quote gratuite sono Cipro e Regno Unito.

INTRODUCTION

The EU-ETS is one of the pillars of European environmental policy to contrast climate change and is an essential market tool for reducing greenhouse gas emissions cost-effectively. At European level, it covers around 10,000 stationary installations, as well as aircrafts operators, and about 40% of the EU's greenhouse gas emissions. In 2020, the European wide target is for the emissions from ETS sectors to be 21% lower than in 2005. Data show that verified emissions of the stationary installations in the EU ETS fell by 42.8% in 2020 compared to 2005, including aviation emissions the reduction is 41.7%. In order to achieve the 2030 target (at least 55% GHG reductions compared to 1990), the ETS has been deeply revised and extended to maritime transport, road transport and buildings. The new ETS should reduce emissions by 61% compared to 2005 (43% for road transport and buildings), while the reduction for the Effort Sharing sectors, not affected by the ETS, will be 40% compared to 2005.

The ETS works according to the cap and trade principle. A cap is set on the total amount of greenhouse gases that can be emitted by the installations and is reduced over time so that total emissions decrease. Within the cap, installations receive or buy allowances which they can trade each other. So, the achievement of the ETS emission reduction targets, unlike national targets for the Effort Sharing sectors, depends on the market balance between 'demand' and 'supply' of emissions/allowances. Demand is represented by emissions from installations, while supply originates from allowances both freely allocated and auctioned or sold. The difference between total allowances and the surrendered units is the amount of allowances available on the market. The deficit or surplus of supply affects the carbon price, with a surge of prices in case of deficit and a fall in case of surplus. In such balance, the emissions cap established at European level and the allowances available on the market, in particular those freely allocated, play a decisive role. Dimos *et al.* (2020) have recently investigated the impact of storing allowances ("banking") on the allowance price showing that banking is a notable, though not the dominant, price determinant.

The trend of the prices of allowances sold at auction on the different European platforms and the related revenues generated by the auction system are monitored for Italy by the GSE on a quarterly basis. The carbon price has changed considerably since 2008, as can be seen in the following graph:

1. In the 1st phase the carbon price fell down to zero because the allowances cannot be banked for the 2nd phase. **2.** A relevant allowances surplus amounts in the 2nd phase, mainly because of economic crisis effects. **3.** The carbon price increase following the ETS revision and allowances backloading. **4.** Downward price due to end of backloading in 2016. **5.** Despite the revision process for the 4th phase the carbon price do not increase in the short term. **6.** Price increase since the half of 2017 with the end of negotiation on ETS revision and beginning (January 2019) of MSR withdrawal. **7.** The carbon price is around 25€ and fell down because of SARS-CoV-2 pandemic.

Source: GSE, 2020[a].

The main reason for the price collapse in 2008-2009 was the allowances surplus following the fall of energy consumption due to the economic crisis. Such surplus led to a fall in demand for allowances. As a result of the emissions contraction the emissions cap already set for the 2nd phase (2008-2012) was less ambitious than expected. With the start of the 3rd phase (2013-2020) prices fluctuated around an average of €5.9/t CO_2 from January 2013 to December 2017. They then soared to a peak of € 27.92/t CO_2 in July 2019. Interestingly, the slowdown of production activities in early 2020, following the lockdown to contain the diffusion of SARS-CoV-2 pandemic, coincides with a rapid price decrease offset by consistent rise in prices in the next months (GSE, 2020[b]). In the first half of 2021 the average price was around €50/t CO_2, reaching the peak of the time series (GSE, 2021). According to the policy scenarios developed by European Commissions to carry out the impact assessment of the new ETS the average carbon price ranges between €45 and €70 in the period from 2026 to 2030 with projected carbon prices in the year 2030 ranging between €50 and €85 (EC, 2021[a]).

The carbon price, as well as the price of any other commodity, is due to cyclical and structural factors. With regard to the structural factors it was of particular importance the ETS reforms which, through the Market Stability Reserve (MSR), withdrew about 900 Mt of CO_2 allowances to a reserve. MSR stabilizes the supply of allowances, reducing it if the market records surplus. Such measure reduced the supply of allowances and led to the price increase observed since the second half of 2017, although interrupted by cyclical or unpredictable events, such as the SARS-CoV-2 pandemic in 2020. In order to reduce the surplus of allowances appear of relevant importance the measures adopted for the 4th phase of ETS as the faster reduction of annual emissions cap from 1.74% per annum in the period 2013-2020 to 4.2% from 2021 onwards (compared to current linear reduction factor of 2.2%), the introduction of annual adjustment of free allocation according to actual production levels and the doubling of the amount of allowances put in the Market Stability Reserve up to 2023.

The ratio between carbon allowances in circulation, especially freely allocated, and verified emissions is therefore a decisive parameter for reducing greenhouse gas emissions by ETS installations. The end of 2020 is the right time to make the final balance about the GHG emissions from ETS installations and the amount of free allowances in the 2nd and 3rd ETS phases in order to assess any allowance surplus and deficit among industrial sectors. The report will analyse in detail Italian data and compare data of the biggest European countries.

1 THE EU EMISSIONS TRADING SCHEME (EU ETS)

The EU Emissions Trading Scheme (EU ETS), established by Directive 2003/87, is one of the European Union's main policies to contrast climate change and is an essential tool for reducing greenhouse gas emissions cost-effectively. The ETS operates in 31 countries (the 27 EU Member States, the United Kingdom which is formally outside the European Union from 2021, Iceland, Liechtenstein, and Norway) and limits emissions from about 10,000 installations in the power sector and manufacturing industry, as well as airlines operating between these countries. The ETS covers around 40% of the EU's greenhouse gas emissions. In 2020, the European wide target is for the emissions from ETS sectors to be 21% lower than in 2005.

The ETS works in accordance with the principle of cap and trade. A cap is set on the total amount of certain greenhouse gases that can be emitted by the installations covered by the system. The cap is reduced over time so that total emissions fall. Within the cap, installations receive or buy allowances which they can trade each other. Up to the end of 2020 installations could use limited amounts of international credits from emissions reduction projects carried out in countries not included in Annex I of the Kyoto Protocol (Clean Development Mechanism, CDM) or included in Annex I of the Protocol (Joint implementation, JI). The limit on the total number of allowances and credits ensures that they have an economic value. In December 2015 the Paris Agreement established a new market mechanism to replace the CDM and JI after 2020. International credits acquired with such projects will no longer be used from 2021.

At the end of each year, installations must surrender a number of allowances equal to the amount of verified emissions. If an installation reduces its own emissions, it can keep the allowances not used to cover future needs, or sell them on the carbon market. Failure to surrender allowances results in the application of penalties laid down in the legislation. Trade creates flexibility and ensures that emissions reduction occurs cost-effectively. High price of CO_2 encourages investment in low carbon technologies.

The EU ETS has undergone several revisions since its beginning. Phase 1, from 2005 to 2007, represented a pilot phase for the next phases, phase 2 from 2008 to 2012 and phase 3 from 2013 to 2020. The legislative framework of the EU ETS for the next trading period - from 2021 to 2030, phase 4 - was revised in early 2018 to meet the EU's emissions reduction targets for 2030, in line with the 2030 Climate and Energy Policy Framework and as part of the EU's contribution to the 2015 Paris Agreement.

In summary, the main features of phase 1 (2005-2007) can be summarized from the following points:

- concerned only CO_2 emissions from power generation and energy-intensive industries;
- almost all allowances were freely allocated;
- the penalty for non-compliance was 40 € per t CO_2.

Phase1 succeeded in establishing a carbon price and building the infrastructure needed to control, communicate and verify the emissions of the installations.

In the absence of reliable emission data, in phase 1 national caps were set on the basis of estimates provided by the Member States based on historical emissions from the installations. As a result, the total amount of allowances allocated exceeded emissions and, as supply far exceeding demand, the price of allowances fell near to zero in 2007. Phase 1 allowances could not be banked for use in phase 2.

Phase 2 (2008-2012) coincided with the first commitment period of the Kyoto Protocol, when the countries in EU ETS had emission reduction targets. The main features of Phase 2 can be summarized as follows:

- lower cap on allowances (approximately 6.5% lower than in 2005);
- Iceland, Liechtenstein and Norway joined the EU ETS;
- several countries have extended the system to N_2O emissions from production of nitric acid;
- the proportion of free allocation has fallen to about 90%;
- a number of countries held auctions for allowances;
- the penalty for non-compliance increased to € 100 per t CO_2;

- businesses were allowed to buy international credits totalling ~1.4 billion t CO_{2eq};
- a Union registry replaced the national registries and the European Union Transaction Log (EUTL) replaced the Community Independent Transaction Log (CITL);
- the aviation sector joined in the EU ETS on 1 January 2012.

In phase 2, the cap on allowances has been reduced and based on actual emissions acquired in the pilot phase 1. However, the economic crisis of 2008 resulted in higher than expected emission reductions which led to a large surplus of allowances and credits and low price of CO_2 throughout the 2nd phase.

The main changes in the 3rd phase (2013-2020) compared to the previous phases are as follows:

- emissions have a single EU-wide cap instead of previous national caps;
- auctioning is the default method for allocating allowances;
- harmonized rules was established for free allocation;
- more gases included (PFCs) and the ETS scope has been extended to sectors not previously included in the system, especially in the ceramics, non-ferrous metals and chemical sectors;
- NER 300 program has set aside 300 million allowances in the reserve for new entrants to finance the deployment of renewable energy technologies and the carbon capture and storage.

The European climate targets linked to the European Green Deal has been set to reducing GHG emissions by at least 55% by 2030 compared to 1990. To implement the increased ambition, on 14 July 2021 the European Commission presented the first series of documents under the 'Fit for 55' package. Among the initiatives adopted to strengthen the role of carbon pricing a pillar action is the revision of the EU Emissions Trading System (ETS), including building and transport as wells as the ETS revision for aviation, and implementation of CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation). Moreover he Commission proposes to gradually extend the current EU ETS to the maritime sector over the period 2023 to 2025.

To achieve the European GHG emissions reduction target for 2030, the EU ETS has been deeply strengthened. The revised EU ETS Directive in the 4th phase of ETS, which will apply from 2021 to 2030, will comply the target through a mix of main measures:

- the overall number of emission allowances will decline at an annual rate of 4.2% from 2021 onwards, compared to 1.74% currently;
- reinforce the Market Stability Reserve (MSR, the mechanism established in 2015 to reduce the surplus of emission allowances and improve the ETS's resilience to future shocks). Between 2019 and 2023, the amount of allowances put in the reserve will double to 24% of the allowances in circulation. The regular feeding rate of 12% will be restored as of 2024; unless otherwise decided in the first review of the MSR in 2021, from 2023 onwards the number of allowances held in the reserve will be limited to the auction volume of the previous year. Holdings above that amount will lose their validity;
- free allocation will be prolonged for another decade and has been revised with more flexible rules to focus on sectors at the highest risk of relocating their production outside of the EU (so called carbon leakage). Annual adjustment of free allocation according to actual production levels will be introduced. The sectors exposed to carbon leakage will receive 100% of their allocation for free. For less exposed sectors, free allocation is foreseen to be phased out after 2026 from a maximum of 30% to 0 at the end of phase 4 (2030);
- to help industry and the energy sector facing the transition to a low-carbon economy through the innovation fund supporting the demonstration of innovative technologies and breakthrough innovation in industry and the modernization fund supporting investments in modernising the power sector and wider energy systems in 10 lower-income Member States.

1.1 Source of Italian data and methodological notes

The analysis was carried out on the data communicated by the EU ETS Italian stationary installations pursuant to the Legislative Decree of 4 April 2006, n. 216 and implementing acts transposing Directives 2003/87 and 2004/101/EC. According to the aforementioned Legislative Decree, subsequently amended by Legislative Decree of 7 March 2008, n. 51, the installations involved send to the Competent National Authority, "*by March 31 of each year, a communication relating to the activities and emissions of the installation in the previous calendar year. The communication shall be accompanied by the verification certificate referred in Article 16.*" (Art. 15, c. 5). Legislative Decree n. 51 was followed by Legislative Decree 30/2013 and the one currently in force since June 2020: Legislative Decree 47/2020, transposing Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018.

Legislative Decree n. 216 establishes the National Committee for the Management of Directive 2003/87/EC and for the management of the project activities of the Kyoto Protocol (Committee) which acts as Competent National Authority and is based at the Ministry of the Environment and Protection of the Territory and the Sea (art. 8). The verification phase of data in the communications received by the Committee "*shall verify the reliability, credibility and accuracy of the monitoring systems, data and information submitted and concerning emissions released by the installation. The audit shall be successful if it does not detect discrepancies between the emission data and information contained in the communication and the actual emissions.*" (Art. 16, c.1).

Verified data allow to assess the fuel mix by installations as well energy consumption. Energy consumption by fuel and related emissions for the year 2005 and the 2010-2020 historical series were analysed. ISPRA has produced, on behalf of the Committee, the database which collects data from the communications sent annually to the Committee by installations. In addition, ISPRA processes, where not directly available in the communications, the energy amount by fuels consumed at installation level. In this respect, the data provided by the installation relating to the fuel calorific values and/or the carbon dioxide emission factors by energy content are used. In the absence of such information, data available in the international literature are applied.

The sectoral classification used at national level has been drawn up by ISPRA since the installations' statements on the main activity sector and considering the sectoral emissions required by the CRF (Common Reporting Format) for the annual submission of the Italian greenhouse gas emissions inventory to the UNFCCC.

The data processed in this report are updated to data submitted to the Emissions Trading Registry of Italy, managed by ISPRA, and on the communications sent to the Committee by April 30, 2021.

The following table shows the list of main activity sectors used for the analysis of Italian data.

Table 1.1 – *List of main activity sectors.*

Extended sector name	Name in the report
All stationary installations	All stationary installations
Power plants	Power plants
All industrial installations (except power plants)	All industrial installations
Combustion of fuels for district heating	District heating
Extraction of fossil fuels	Extraction
Installations for LNG regasification	LNG regasification
Installations for waste incineration	Waste incineration
Manufacture of ceramics	Ceramics
Manufacture of glass	Glass
Mechanic industry	Mechanics
Natural gas pipeline compression	NG pipeline compression
Production of bulk chemicals	Bulk chemicals
Production of cement clinker	Cement clinker
Production of food & beverage	Food & beverage
Production of lime, or calcination of dolomite/magnesite	Lime, or calcination…
Production of paper or cardboard	Paper or cardboard
Production of pig iron or steel (integrated cycle / electric arc)	Pig iron or steel (IC / el.)
Production of pulp	Pulp
Production of textiles and fabrics	Textile
Production or processing of non-ferrous metals	Non-ferrous metals
Refining of mineral oil	Refining of mineral oil
Other sectors	Other sectors

The Mann-Kendall test has been carried out to check the statistical significance of emissions trend. The purpose of the Mann-Kendall test (Mann 1945, Kendall 1975, Gilbert 1987) is to assess if there is a monotonic upward or downward trend of the variable of interest over time. A monotonic upward or downward trend means that the variable consistently increases or decreases through time, but the trend may or may not be linear. The test can be used instead of a parametric linear regression analysis, which can be used to test if the slope of the estimated linear regression line is different from zero. However the regression analysis requires that the residuals from the fitted regression line be normally distributed, while the non-parametric (distribution-free) Mann-Kendall test do not need such assumption. Moreover, the Mann-Kendall test evaluates the full trend limiting the misleading interpretation due to outstanding emissions decrease recorded for contingent reasons. The Mann-Kendall test is not aimed to assess the effectiveness of ETS in reducing greenhouse gas emissions, the assessing of carbon pricing efficacy as causal driver of emissions reduction needs econometric modelling approaches (Best *et al.*, 2020) not considered in this report.

1.2 ETS installations, GHG emissions and energy consumption

This chapter will analyse the number of ETS installations, the GHG emissions and fuel energy consumption. The estimated emissions from 2005 to 2012 are available to reflect the current ETS scope, but such estimates are not available at sectoral level, so the sectoral analyses take into account emissions according to the legislation in force in the emission year. Emissions in the period 2005-2012 including the estimate due to ETS revision are reported only at national level.

1.2.1 *Number of stationary installations and main activity sectors*

The number of ETS installations shows an increasing trend from 2005 to 2013, from 942 plants to peak of 1,135. Subsequently, a steady decrease has been recorded with 974 installations in 2020. The increase recorded in 2013 was mainly due to ETS revision with substantial scope extension for some industrial sector such as ceramics, non-ferrous metals, steel and chemical sectors. For the latter sector it

should be emphasized that the installations considered in the analysis are mainly combustion plants supporting the production of chemicals.

In 2020, power plants, together with those for district heating, accounted for almost a fifth of total ETS installations (19%). Among the most numerous industrial installations, the number of paper industry plants decreased by 22.6% from 2005 to 2020, and by 3.9% since 2013. The number of installations of sectors as ceramics, bulk chemicals and electric furnace steel industries increased since 2005 for the ETS revision. The change rate since 2013 is therefore more useful for such sectors. The number of installations in all the mentioned sectors decreased since 2013.

Table 1.2 – *Installation number by main activity sector. Percentage changes in the 2005-2020, 2013-2020 periods and 2020 share are reported. Activity sector in decreasing order according to 2020 emissions.*

Activity sector	2005	2010	2015	2020	Δ% 2005-2020	Δ% 2013-2020	% 2020
Power plants	137	174	143	130	-5.1%	-17.7%	13.3%
Refining of mineral oil	17	17	14	14	-17.6%	-12.5%	1.4%
Cement clinker	52	52	37	29	-44.2%	-39.6%	3.0%
Bulk chemicals#	73	72	84	84	15.1%	-1.2%	8.6%
Pig iron or steel (IC)	4	3	3	3	-25.0%	0.0%	0.3%
Pig iron or steel (el.) #	40	44	81	78	90.2%	-7.1%	8.0%
Paper or cardboard	159	149	124	123	-22.6%	-3.9%	12.6%
District heating	36	62	55	55	52.8%	5.8%	5.6%
Ceramics#	34	24	126	116	241.2%	-15.9%	11.9%
Glass	55	53	48	50	-9.1%	2.0%	5.1%
Food & beverage	93	135	117	105	12.9%	-15.3%	10.8%
Lime, or calcination…	31	34	26	23	-25.8%	-25.8%	2.4%
Extraction	13	12	13	11	-15.4%	-15.4%	1.1%
Mechanics	60	71	61	46	-23.3%	-30.3%	4.7%
Non-ferrous metals#	0	0	12	14		0.0%	1.4%
NG pipeline compression	19	19	18	21	10.5%	10.5%	2.2%
Other sectors	63	65	66	42	-33.3%	-40.8%	4.3%
LNG regasification	1	2	3	3	200.0%	0.0%	0.3%
Waste incineration	11	8	8	9	-18.2%	12.5%	0.9%
Textile	44	33	22	18	-59.1%	-28.0%	1.8%
Total	**942**	**1,029**	**1,061**	**974**	**3.4%**	**-14.2%**	

Sectors affected by ETS scope extension since 2013.

Power plants represent the highest share of installations (13.3%), followed by paper or cardboard (12.6%), ceramics (11.9%), and food & beverage sectors (10.8%). The four sectors have almost half of all installations in 2020 (48.7%).

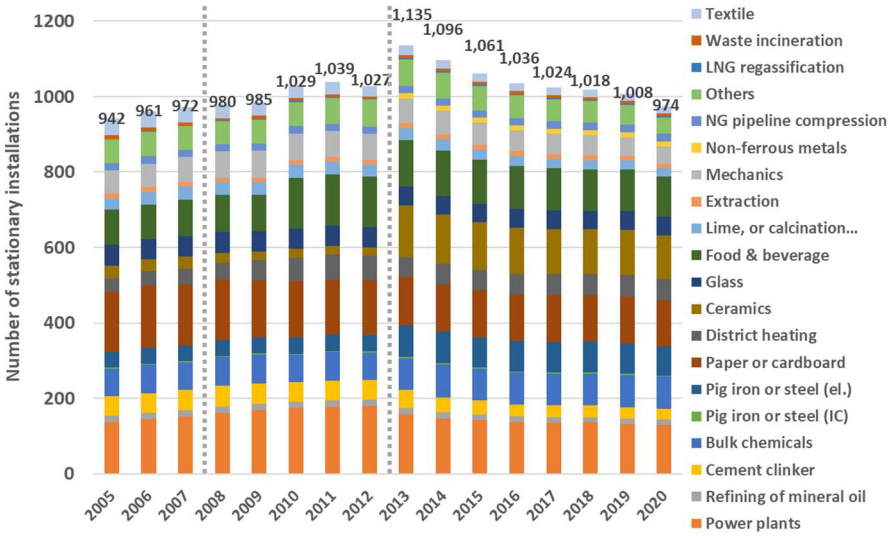


Figure 1.1 – *Trend of installations number by main activity sector. The dotted lines divide the three ETS phases.*

1.2.2 *Verified emissions and allocated allowances*

ETS emissions are averagely about 37% of total GHG emissions since 2005 (ISPRA, 2021[a]). Following the ETS revision in phase 3, EU Member States estimated the emissions from 2005 to 2012 to reflects the current ETS scope. Considering also such estimates, the share of ETS emissions in 2005 rises to 42% with a peak of 42.2% in 2007. Since 2005, there has been a decreasing trend of ETS emissions share. The provisional estimate of emissions for 2020 (ISPRA, 2021[b]) shows a further reduction in the ETS emissions share with about 33% of total emissions.

ETS emissions fell significantly in 2009 as a result of production activity shrinking due to the economic crisis. After a slight recovery, the trend remained decreasing even in the following years despite the slight economy recovery after 2014. Industry value added in 2020 grew by about 9% compared to 2014, while ETS emissions decreased by 7.6% over the same period. Therefore, although the ETS installations do not represent the entire industrial sector, it is possible to infer a decoupling between GHG emissions and industry added value. As for 2020 the contraction is also due to the SARS-CoV-2 pandemic effect.

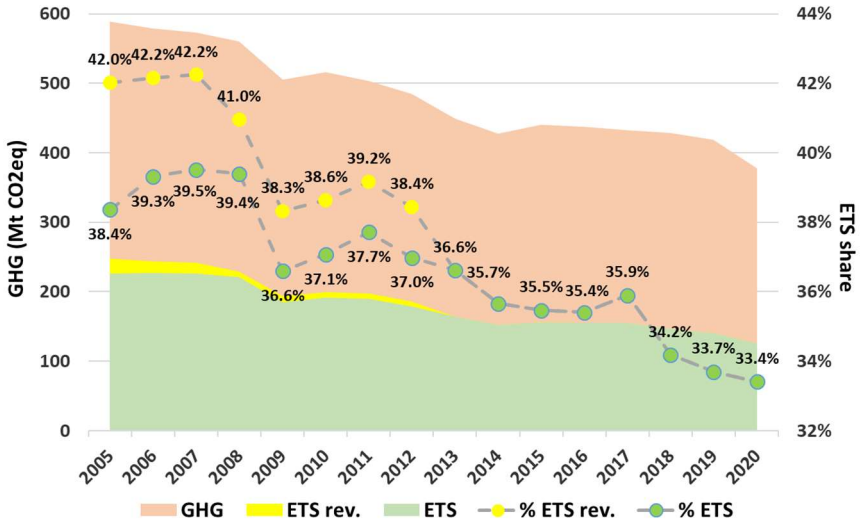


Figure 1.2 – *GHG emissions trend by ETS installations. The emissions estimate from 2005 to 2012 to reflect current ETS scope is also reported.*

As already stated, analyses at sectoral level do not include the contribution of emissions estimated for the period 2005-2012 following the ETS revision. Power plants represent the predominant sector, exceeding 50% of ETS emissions in 2020. This is followed by refining of mineral oil sector (12% of emissions) and cement clinker (9%). The emissions by bulk chemicals sector account for about 4%. The four sectors represent more than 75% of ETS emissions. The emissions share of these sectors decreased since 2005 from 84.7% in 2005 to 76.9% in 2020.

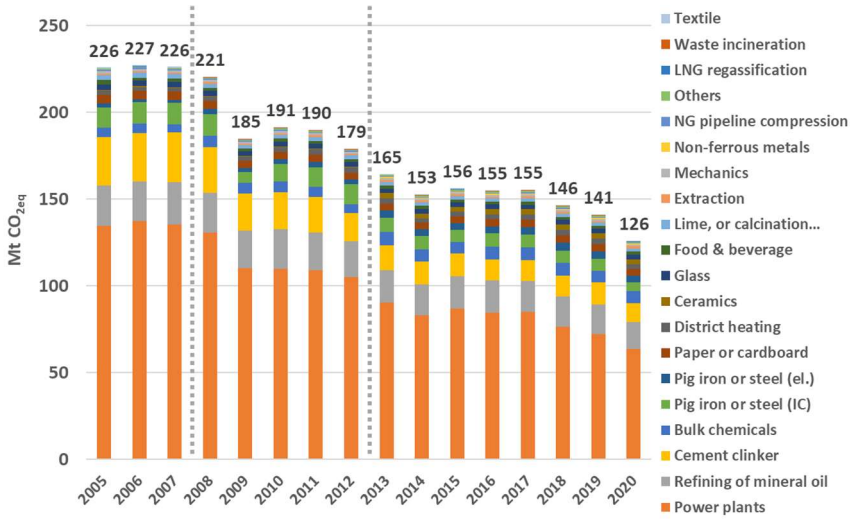


Figure 1.3 – *Trend of GHG emissions by main activity sector. The dotted lines divide the three ETS phases.*

Table 1.2 shows emissions from each sector. There is a considerable heterogeneity concerning the trend for each sector. Considering the estimates to reflect the current ETS scope, the overall emissions reduction in 2020 is 49.1% compared to 2005. Sectoral changes cannot be calculated considering the scope extension, so comparison with 2013 emissions is more useful. Only few sectors increased the emissions since 2013, all contributing the upper 10% cumulative emissions. The overall decrease since 2013 is of 23.4%. Sectors contributing more than 75% of emissions show consistent reductions compared to 2013 ranging from 29.5% for power plants to 12.9% for bulk chemicals.

Table 1.2 – *Sectoral emissions ($MtCO_2eq$). Changes in the 2005-2020, 2013-2020 periods and cumulative emissions of 2020 are reported. Dotted lines are drawn at least 75% and 95% of 2020 emissions. Total emissions with the 2005-2012 estimate to reflect current ETS scope are reported. Mann-Kendall trend test significance: * $p<0.05$; ** $p<0.01$.*

Activity	2005	2010	2015	2020	Δ% 2005-2020	Δ% 2013-2020	Cumulative % 2020
Power plants	134.5	109.7	86.9	63.8	-52.5%**	-29.5%*	50.6%
Refining of mineral oil	23.5	22.9	18.7	15.2	-35.4%**	-17.5%*	62.7%
Cement clinker	27.6	21.4	13.0	11.1	-60.0%**	-22.5%*	71.5%
Bulk chemicals#	5.7	6.3	6.8	6.9	20.6%	-12.9%	76.9%
Pig iron or steel (IC)	12.6	10.0	6.7	5.0	-60.1%**	-38.6%*	80.9%
Pig iron or steel (el.) #	1.3	2.8	3.9	3.9	195.0%**	-5.3%	84.0%
Paper or cardboard	5.0	4.4	3.9	3.9	-22.2%**	-1.8%	87.1%
District heating	2.1	2.7	2.6	2.8	36.7%**	-11.8%	89.4%
Ceramics#	0.7	0.4	2.9	2.8	309.0%	-4.4%	91.6%
Glass	3.0	2.7	2.5	2.7	-9.6%	4.7%	93.7%
Food & beverage	2.7	1.7	1.7	1.8	-35.5%	4.4%	95.1%
Lime, or calcination…	2.7	2.2	1.8	1.7	-37.1%**	-21.1%	96.4%
Extraction	0.9	0.8	1.1	1.4	55.8%	24.4%	97.6%
Mechanics	1.3	1.3	1.2	0.8	-34.3%**	-26.1%	98.2%
Non-ferrous metals#	0.0	0.0	0.6	0.6		2.4%	98.7%
NG pipeline compression	0.8	0.9	0.4	0.5	-31.0%	3.1%	99.2%
Other sectors	0.8	0.6	0.7	0.5	-33.0%	-23.0%	99.6%

LNG regasification	0.1	0.1	0.1	0.2	256.4%**	146.3%**	99.8%
Waste incineration	0.2	0.3	0.2	0.1	-5.7%	-2.8%	99.9%
Textile	0.6	0.3	0.2	0.1	-75.3%**	-41.9%	100.0%
All industrial installations	**91.5**	**81.8**	**69.3**	**62.2**	**-32.0%****	**-15.9%**	
All installations	**226.0**	**191.5**	**156.2**	**126.0**	**-44.2%****	**-23.4%***	
All installations ETS rev.	**247.5**	**199.5**	**156.2**	**126.0**	**-49.1%****		

Sectors affected by ETS scope extension since 2013.

The emissions from industrial installations was 62.2 $MtCO_2eq$ in 2020. The emissions share in ETS emissions shows an increasing trend in recent years, from 45% in 2013 to 49.4% in 2020. Figure 1.4 shows the share of emissions in the activity sectors which account for at least 95% of 2020 emissions. From 2005 to 2020, the share of power sector decreased from 59.5% to 50.6%. The cement clinker sector also shows a sharp contraction of share, while bulk chemicals sector doubles its share since 2005.

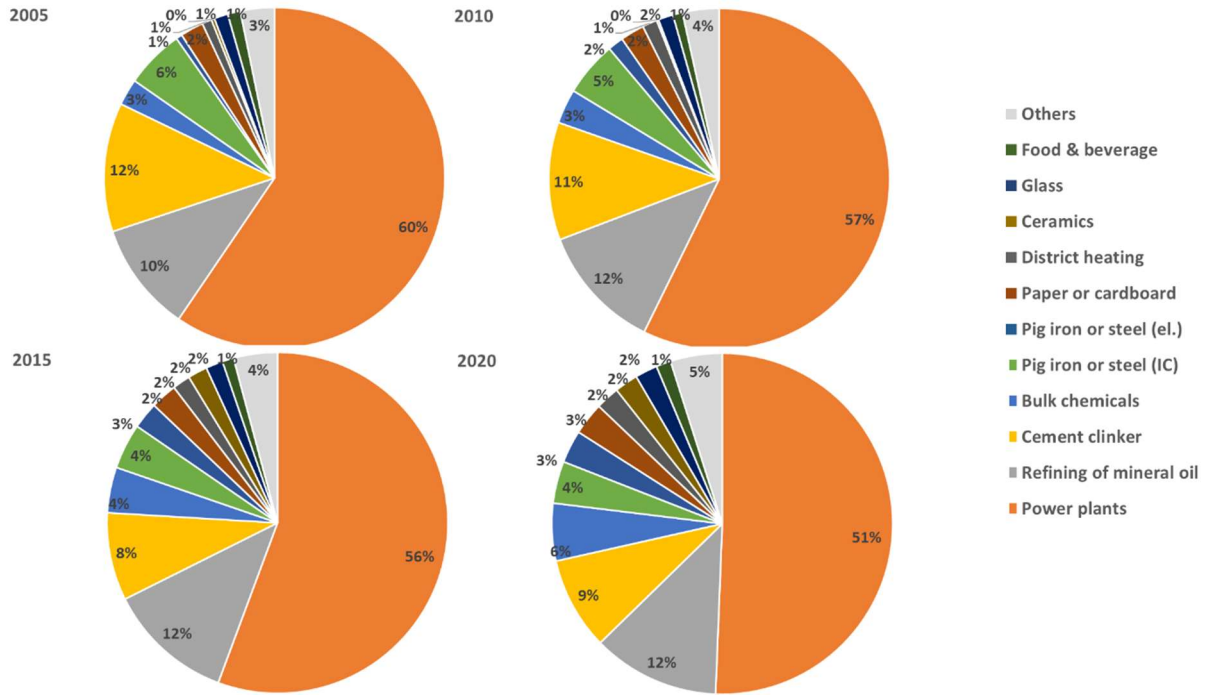


Figure 1.4 – *Total ETS emissions share by main activity sector.*

Figure 1.5 shows the sectoral breakdowns for the installations number and emissions. Most of the emissions are due to a relatively small number of installations by sectors with the highest emissive intensity per plant, such as power plants, refining of mineral oil, cement clinker, and integrated cycle pig iron or steel installations.

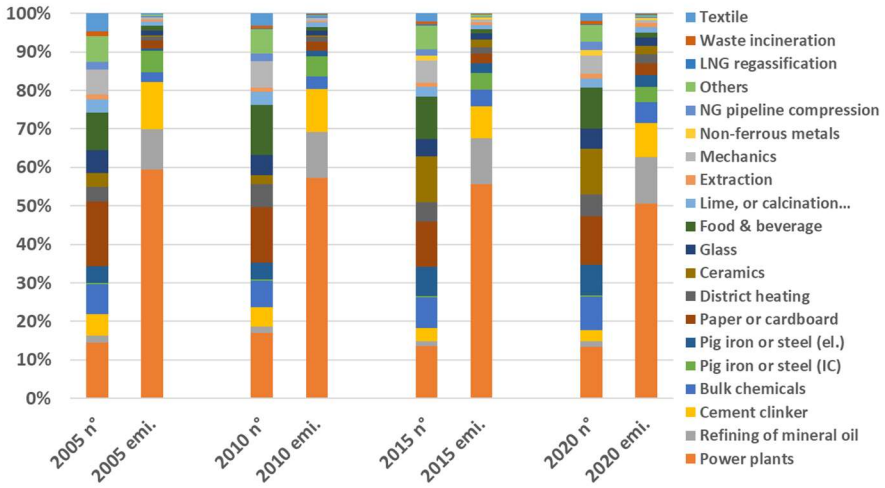


Figure 1.5 – *Share of installations number and emissions by main activity sector.*

The cumulative share of emissions by sector therefore shows a steep surge already with the first top emitting sectors. Emissions are more "concentrated" at sectoral level in 2005 than in 2020. The 95% of emissions in 2005 was reached by about eight sectors, while in 2020 eleven sectors reached the 95% threshold. Such outcome is due to the significant emissions reduction recorded for the first three sectors: power sector, cement clinker and refining of mineral oil.

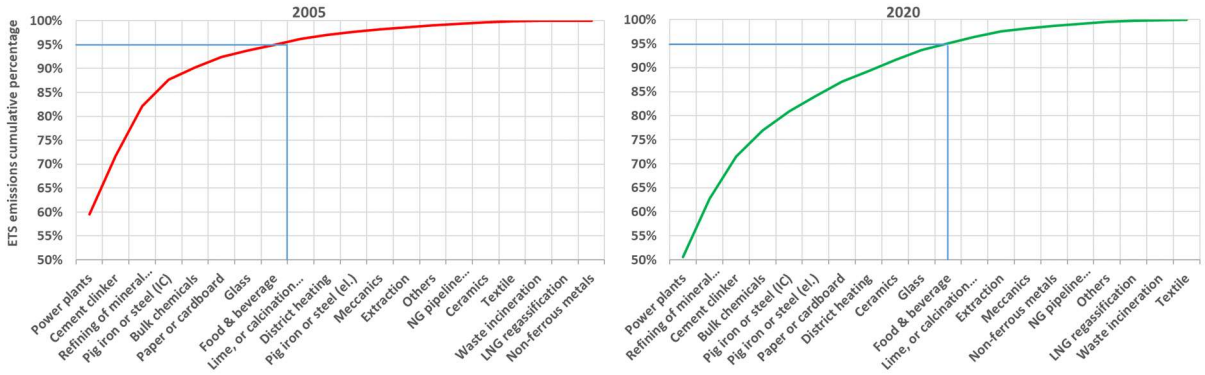


Figure 1.6 – *Trend of cumulative percentage of emissions by main activity sector in decreasing emissions order.*

The average emissions intensity per installation decreased by 46.1% in 2020 compared to 2005 with considerable heterogeneity at sectoral level (Table 1.3). The sectors characterized by installations with higher emissions are, in descending order: integrated-cycle pig iron or steel, refining of mineral oil, power plants and cement clinker. The average emissions intensity per installation for such sectors decreased from 2005 to 2020 from 21.5% for refining of mineral oil to 56% for integrated-cycle pig iron and steel. Overall, the average intensity of industrial sectors in 2020 is 73.7 t CO_2eq per plant, with a reduction of 35.2% compared to 2005.

Table 1.3 – *Emissions intensity by installation (t CO_2eq per plant). The percentage changes in the periods 2005-2020 and 2013-2020 are reported.*

Activity	2005	2010	2015	2020	Δ% 2005-2020	Δ% 2013-2020
Power plants	981.5	630.3	608.0	490.8	-50.0%	-14.3%
Refining of mineral oil	1,385.0	1,345.1	1,335.1	1,087.3	-21.5%	-5.7%
Cement clinker	531.4	411.2	351.4	381.5	-28.2%	28.2%

Bulk chemicals#	78.1	87.0	80.4	81.8	4.8%	-11.9%
Pig iron or steel (IC)	3,154.3	3,318.3	2,246.8	1,677.3	-46.8%	-38.6%
Pig iron or steel (el.) #	33.1	64.8	48.6	50.1	51.3%	2.0%
Paper or cardboard	31.4	29.3	31.5	31.5	0.5%	2.2%
District heating	57.5	43.2	48.0	51.5	-10.5%	-16.6%
Ceramics#	20.2	15.1	23.0	24.2	19.9%	13.8%
Glass	53.8	51.2	52.6	53.5	-0.6%	2.6%
Food & beverage	29.3	12.9	14.4	16.7	-42.8%	23.3%
Lime, or calcination…	87.1	63.9	70.6	73.8	-15.2%	6.4%
Extraction	69.6	68.3	88.4	128.3	84.1%	47.0%
Mechanics	21.3	18.5	19.5	18.3	-14.3%	6.1%
Non-ferrous metals#			51.4	44.7		2.4%
NG pipeline compression	41.9	48.5	24.4	26.1	-37.6%	-6.7%
Others	12.9	9.4	10.6	13.0	0.5%	30.2%
LNG regasification	64.5	68.6	43.1	76.6	18.8%	146.3%
Waste incineration	14.1	42.0	23.8	16.3	15.2%	-13.6%
Textile	12.9	10.0	10.6	7.8	-39.6%	-19.3%
Total average	**239.9**	**186.1**	**147.2**	**129.4**	-46.1%	-10.7%
Industrial average	**113.7**	**95.7**	**75.5**	**73.7**	-35.2%	-2.7%

Sectors affected by ETS scope extension since 2013.

The emissions distribution observed for sectoral emissions with the steep growth of cumulative emissions for the first top emitting sectors is even more evident for individual installations (Figure 1.7). In 2005, the threshold of 95% emissions were reached by 31.4% of plants (296), while in 2020 the number of plants increased to 408 (41.9%) to reach 95% of total emissions.

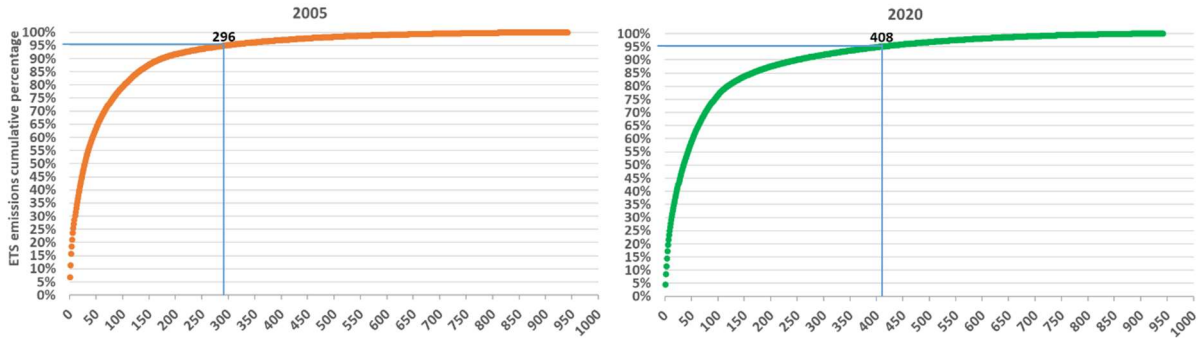


Figure 1.7 – *Trend of cumulative percentage of emissions by installation in decreasing order.*

Results show that the emissions by ETS installations follow a power law distribution, i.e. few classes have a notable amount of emissions and next classes have fewer and fewer emissions. Given the distribution, the natural logarithmic transformation of emissions is useful to define the emission classes. Twenty emissive classes have been defined with a regular step between zero and the maximum value of the natural logarithm of emissions reached in the period 2005-2020. In this way the frequency of the installations is divided into increasingly large emissive classes allowing to observe the log-normal distribution of ETS emissions.

The following graphs show the frequency of installations per class of emissions. It is clear the shape change over time. Distributions are considerably wide around the average and quite asymmetric for the power plants. The standard deviation of curves from 2005 to 2020 is from four to five times the average, an insight of significant installation emissions size variability. From 2005 to 2020 the average emissions per plant ± the standard deviation ranges from 239.9±886.4 kt CO_2eq to 129.4±414.9 kt CO_2eq.

Any activity sector has a specific distribution depending upon the installations size. In particular, for power plants there is a considerable asymmetry with a rather wide tail to the left, while for the industrial sectors taken together there is a less asymmetrical distribution. Power plants average intensity decreased

from 981.5±1,841.2 kt CO_2eq to 490.8±744.8 kt CO_2eq from 2005 to 2020, while industrial sectors decreased over the same period from 113.7±486.4 kt CO_2eq to 73.7±300.9 kt CO_2eq.

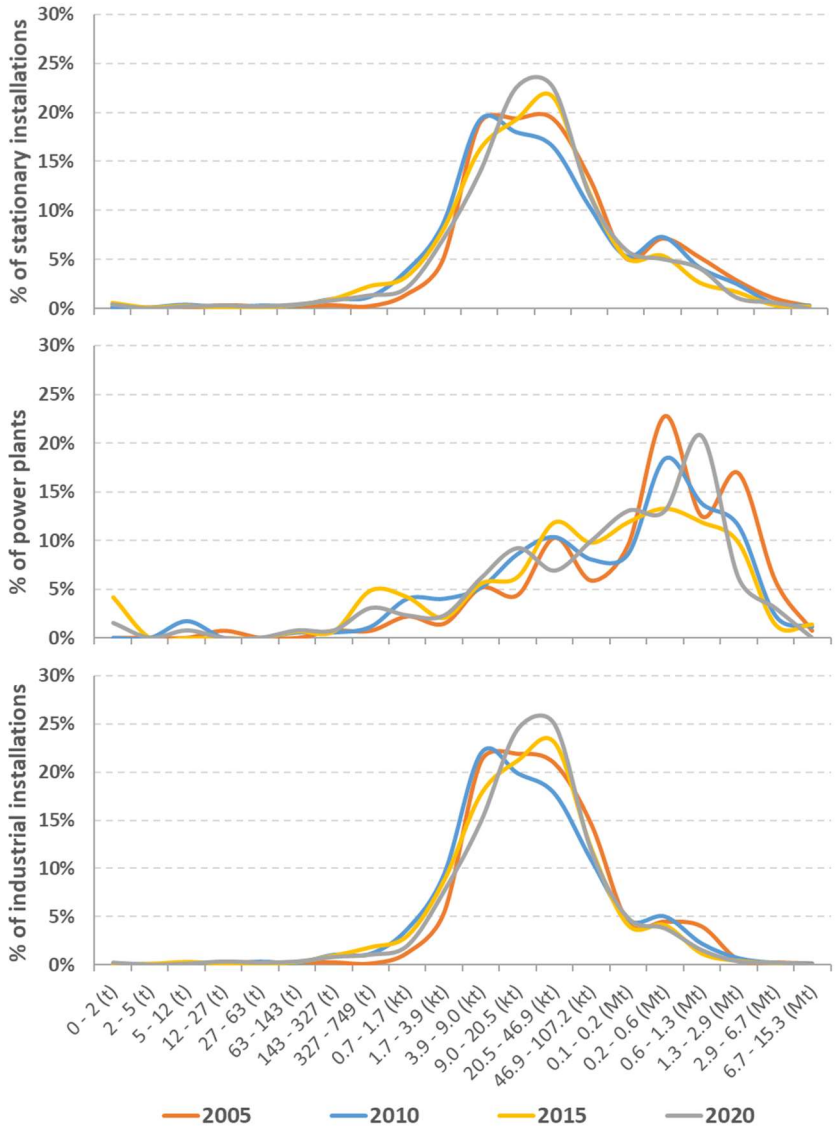


Figure 1.8 – *Frequency distribution of installations by emissions class.*

1.2.3 *Ratio of allocated allowances to verified emissions*

In the 1st and 2nd phases of the ETS, from 2005 to 2012, the common method to allocate allowances was on the basis of their historical emissions and the allowances was freely allocated. Since 2013, with the start of the 3rd phase, auctioning has been the common method of allocating allowances. For the freely allocated allowances, harmonised criteria was applied to sectors on benchmark basis for final products (Decision 2011/278/EU).

The ratio between free allowances and verified emissions allows to assess any over or under allocation (Gaudioso *et al*., 2009). The ratio between free allowances and verified emissions has been developed at sectoral level, a simplified approach to the methodology proposed by Ellerman and Buchner (2006) which nevertheless allows to detect any surplus (ratio > 1) or deficit (ratio < 1) of allowances.

Figure 1.9 shows remarkable surplus of free allowances from 2009 to 2012 mainly due to the contraction of industrial activities as a result of the economic crisis. The emissions reduction constrained

demand for allowances leading to lower carbon prices. To stabilise the carbon market, the European Commission postponed the auctioning of 900 million allowances until 2019-2020 reducing the auction volume in the period 2014-2016, the so-called backloading, and transferring the back-loaded allowances in the Market Stability Reserve. The reserve aims to correct the large surplus of emission allowances and to make the system more resilient to imbalances between supply and demand.

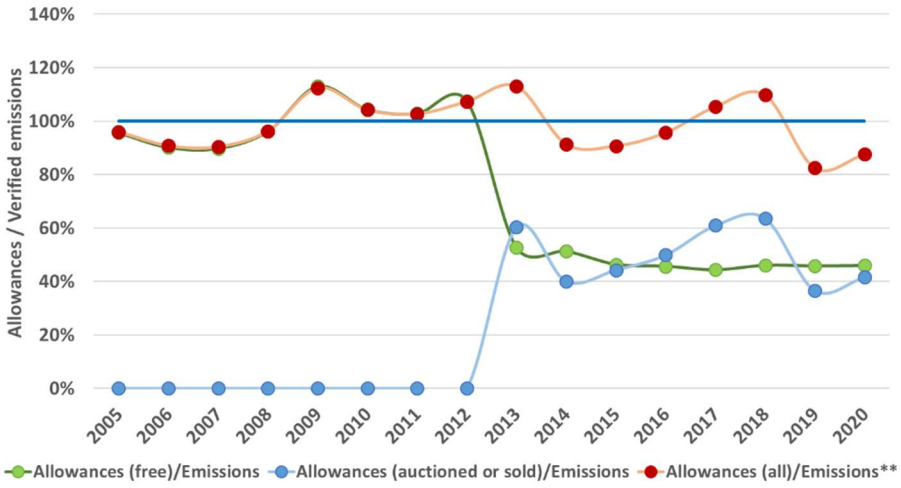


Figure 1.9 – *Percentage of allowances compared to verified emissions. ** Data account for the estimates to reflect the current ETS scope for allowances and emissions.*

Figure 1.10 shows that free allowances surplus from 2009 to 2012 concerned the industrial installations. Although since the beginning of 3rd phase the surplus dropped swiftly, with the lockdown in 2020 for the SARS-CoV-2 pandemic, it is reasonable to expect a further surplus of free allowances for some sector.

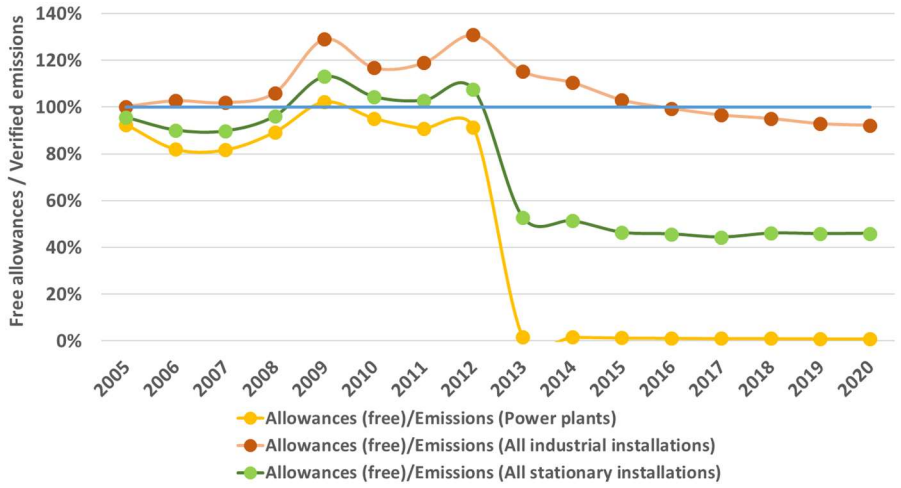


Figure 1.10 – *Ratio of freely allocated allowances to verified emissions for all stationary installations, power plants and industrial installations.*

Figure 1.11 shows the sectoral ratios between cumulative free allowances and cumulative verified emissions in phases 2 and 3. In the power plants since 2013 (phase 3), free allowances are allocated only for heat production. Despite the measures to stabilise the carbon market and the introduction of benchmark criteria, the contraction of production activities, which in some sectors is still particularly significant, shows an over-allocation of free allowances even in the 3rd phase. The sectors significantly affected by such surplus even in the 3rd phase are cement clinker (ratio 1.34), integrated cycle pig iron or steel (1.96), ceramics (1.05), lime or calcination of dolomite/magnesite (1.28), waste incineration

(1.38), textile (1.16). It is also notable the increasing surplus of free allowances from 2nd to 3rd phase recorded for relevant sectors as cement clinker and pig iron or steel despite the free allocation methods for the two phases are very different and more market based in the 3rd phase.

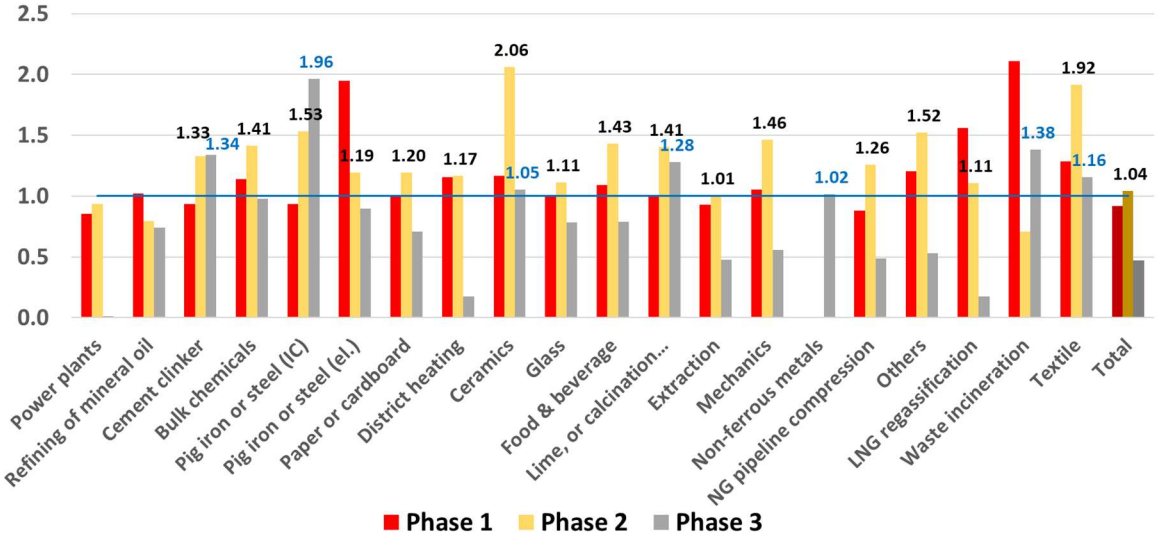


Figure 1.11 - *Ratio of freely allocated allowances to verified emissions by main activity sector in the three ETS phases. Sectors in descending order of verified emissions in 2020.*

The cumulative ratios for phase 2 plus phase 3 shown in Figure 1.12 highlight the sectors with surplus of free allowances. The surpluses of free allowances cumulated compared to verified emissions range from 1.8% for non-ferrous metals to 75.8% for integrated cycle pig iron or steel. The whole system recorded cumulative deficit of free allowances of 27.1%, therefore the surplus is over than offset by the allowances demand from power sector.

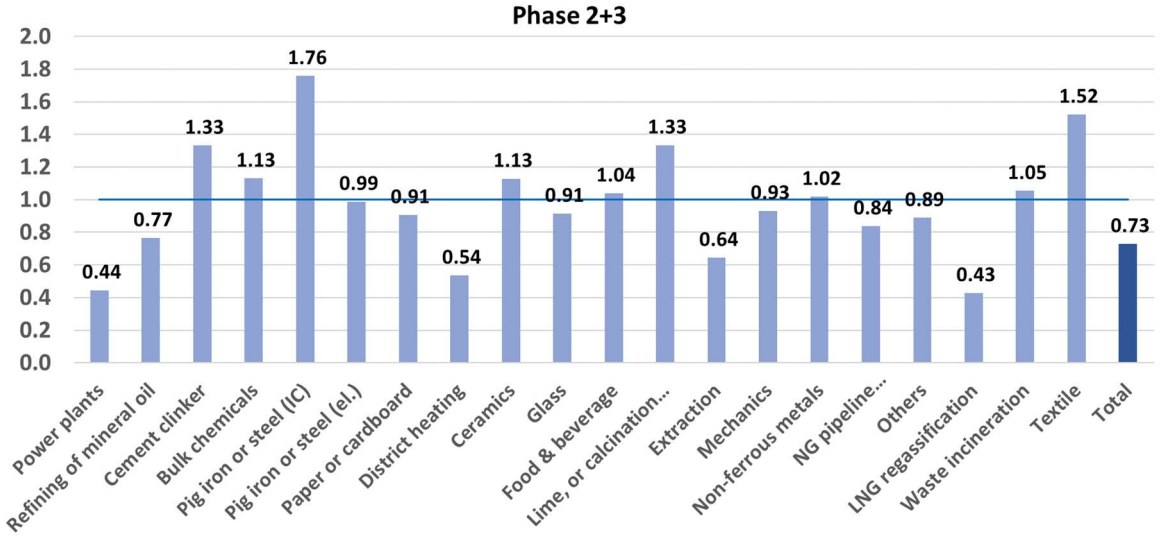


Figure 1.12 - *Ratio of freely allocated allowances to verified emissions by main activity sector since the beginning of ETS 2nd phase. Sectors in descending order of verified emissions in 2020.*

1.2.4 *Fuel consumption and emissions*

The analysis of energy consumption and emissions can only be carried out on the installations actually operating in the indicated year. The estimates to reflect the current ETS scope are not available for such analysis.

ETS energy consumption, including by fossil fuels and bioenergy, amounted to 69.5 Mtoe in 2005, 36.7% of gross inland energy consumption. In 2020, ETS energy consumption fell to 44.5 Mtoe, 31.3% of provisional estimate of gross inland consumption. The trend of energy consumption of the ETS installations follows the trend of gross inland consumption but the ETS share decreased although with some fluctuations.

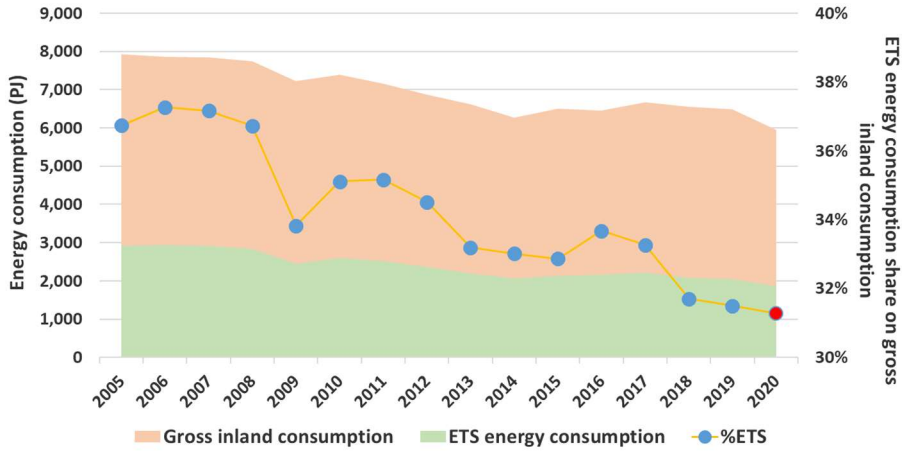


Figure 1.13 – *Trend of gross inland energy consumption, ETS energy consumption, and ETS share of energy consumption on gross inland consumption. Provisional estimate for 2020 gross inland consumption.*

Figure 1.14 shows the energy consumption by sector in the years 2005, 2010, 2015 and 2020. The sectors are arranged in descending order of emissions in 2020. The energy consumption fell by 36% from 2005 to 2020, while GHG emissions decreased by 44.2% and in particular emissions by fuel consumption decreased by 42.9%.

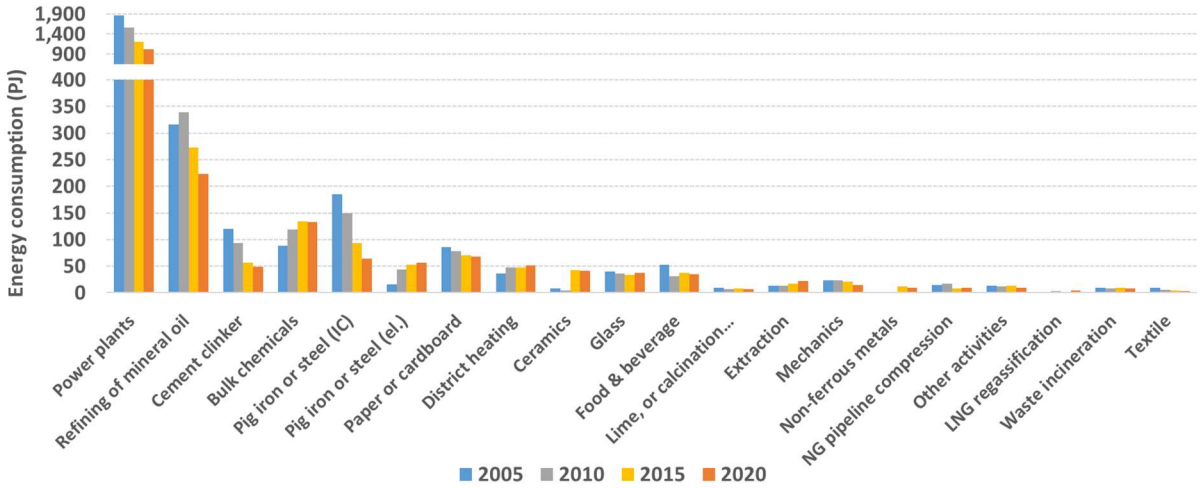


Figure 1.14 – *Fuel energy consumption by main activity sector. Sectors in descending order of emissions in 2020.*

Emissions from plants are mainly due to fossil fuels consumption (combustion or other processes). In some sectors a not negligible share of emissions is due to processes of transformation of fuels or inorganic matter (calcination, clinker production, etc.). In Figure 1.15 emissions are divided by fossil fuels consumption and by process involving inorganic matter. The sectors with the highest incidence of the latter emissions are cement clinker (63.7% of total emission in 2020) and lime or calcination of dolomite/magnesite (87.4%), followed by glass (21.4%), ceramics (15.9%), pig iron or steel (8.2%), and refining of mineral oil (2.6%). In the bulk chemical sector the production of formaldehyde, carbonate, bicarbonate, carbon black, etc. accounts for negative values.

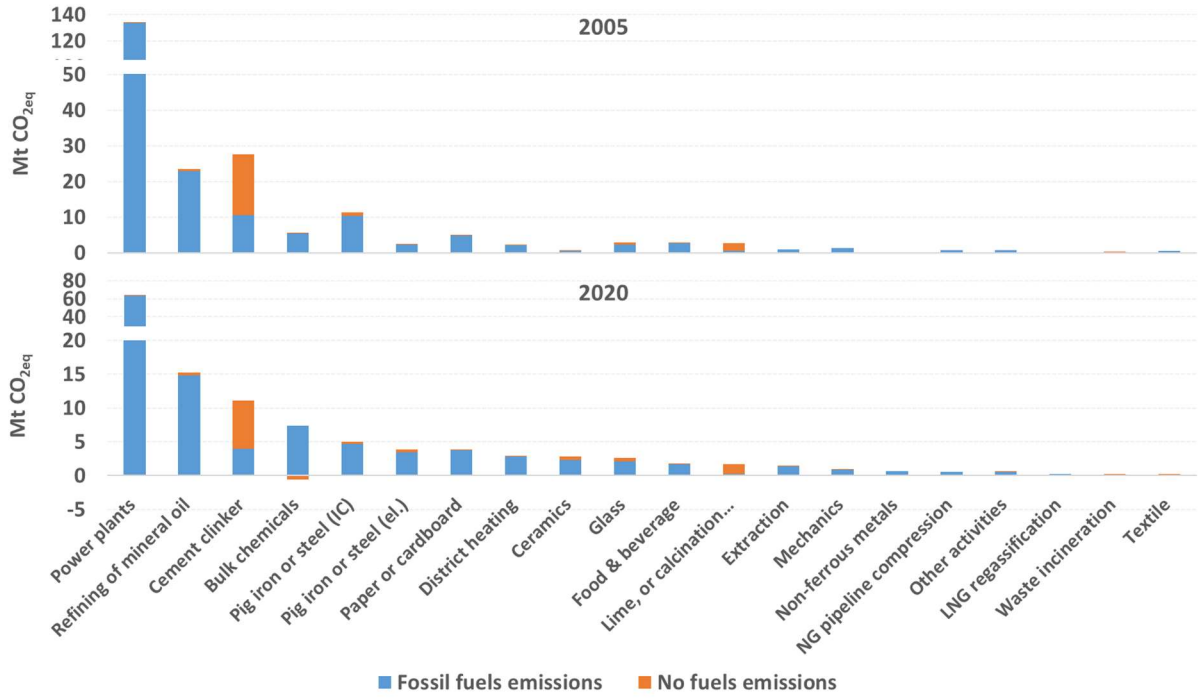


Figure 1.15 – *Sectoral emissions from fossil fuels consumption and no fuels emissions in 2005 and 2020. Sectors in descending order of emissions in 2020.*

Emissions by fuel consumption account for more than 90% of ETS emissions (91.9% in 2020) and fell by 42.9% from 2005 to 2020. Considering only industrial sectors, emissions by fuel consumption represent 83.6% in 2020. Emissions by no fuel show a greater reduction (-54.4%), mainly due to the sharp contraction of cement industry activities.

The emission factors carried out in this report should not be confused with emission factors by fuels reported in the National Inventory Report (ISPRA, 2021[a]; Annex 6), which directly refer to fuel carbon content and CO_2 emissions for fuel combustion. The emission factors elaborated here always refer to the specific activity sector use of fuels, not always for combustion purpose.

The emission factors by sector, given by the ratio of GHG emissions to fuel energy content (fossil fuels and bioenergy), decreased significantly in the period 2005-2020. The test of Mann-Kendall is statistically significant ($p<0.05$) both for power plants and industrial installations since 2005, while the reduction trend since 2013 is statistically significant only for power plants (Figure 1.16).

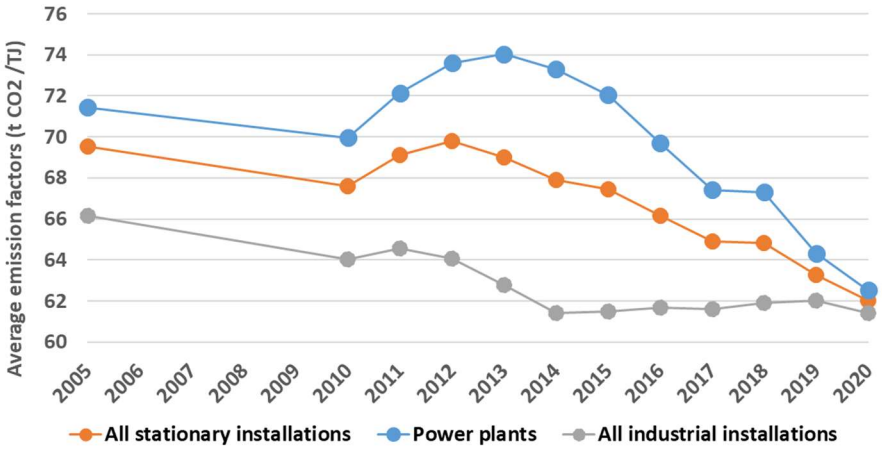


Figure 1.16 – *Trends of fossil fuels emission factors.*

Table 1.4 shows the variation of emission factors in the period 2005-2020 and 2013-2020 by main activity sectors. The sector of integrated-cycle pig iron or steel recorded highly significant increasing emission factors (+23.3% in 2020 compared to 2005). Overall, sectors showing an increase of the emission factor compared to 2005 account for 8.7% of ETS emissions in 2020, about the same share was recorded in 2005.

Table 1.4 – *Emission factors from fuel consumption by main activity sector (t CO_2eq/TJ), percentage changes in the period 2005-2020 and 2013-2020. Mann-Kendall trend test significance: * p<0.05; ** p<0.01.*

Activity	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Power plants	71.4	70.0	72.0	62.5	-12.5%*	-15.5%**
Refining of mineral oil	72.2	67.2	66.5	66.4	-8.0%	-3.1%
Cement clinker	88.7	89.2	85.6	82.9	-6.5%**	-5.1%**
Bulk chemicals	60.9	56.6	55.3	55.6	-8.8%	-2.7%
Pig iron or steel (IC)	62.1	62.4	66.6	73.7	18.8%**	14.1%**
Pig iron or steel (el.)	70.9	62.6	64.8	61.6	-13.1%	-7.5%
Paper or cardboard	55.7	55.7	55.7	55.8	0.2%	0.1%
District heating	56.1	55.9	55.3	55.3	-1.4%*	-0.1%
Ceramics	66.3	67.9	56.8	57.2	-13.8%	0.4%
Glass	58.8	59.4	58.6	56.9	-3.2%*	-1.3%
Food & beverage	50.9	56.3	45.8	48.2	-5.4%	-4.3%
Lime, or calcination…	62.2	64.5	41.3	30.0	-51.7%**	-36.6%**
Extraction	67.0	59.4	57.9	63.1	-5.8%*	7.9%
Mechanics	56.0	56.3	56.1	56.1	0.3%	0.0%
Non-ferrous metals			54.3	70.1	-3.6%	-3.6%
NG pipeline compression	55.4	55.6	56.7	56.0	1.2%	0.2%
Other activities	52.4	50.6	50.7	55.2	5.4%	3.4%*
LNG regasification	55.4	55.7	55.0	55.8	0.7%	-1.1%
Waste incineration	20.5	39.7	20.2	18.0	-12.2%	4.9%
Textile	56.0	57.8	60.1	55.3	-1.2%	2.6%
All stationary installations	**69.5**	**67.6**	**67.4**	**62.0**	**-10.8%****	**-10.1%****
All industrial installations	**66.1**	**64.0**	**61.5**	**61.4**	**-7.1%***	**-2.1%**

Figures 1.17 and 1.18 show the percentage changes of sector emission factors in the periods 2005-2020 and 2013-2020. The integrated cycle steel industry shows the largest increase since 2005, while on the other end with the highest reductions there are installations for production of lime or calcination of dolomite/magnesite, production of ceramics, and installations of electric furnace steel industry.

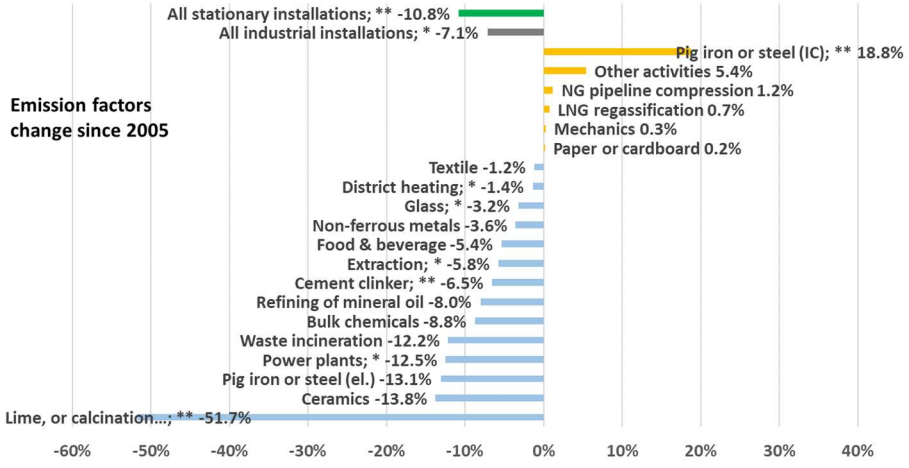


Figure 1.17 – *Percentage change from 2005 to 2020 of emission factors from fuel consumption by main activity sector. Mann-Kendall test significance: * p<0.05; ** p<0.01.*

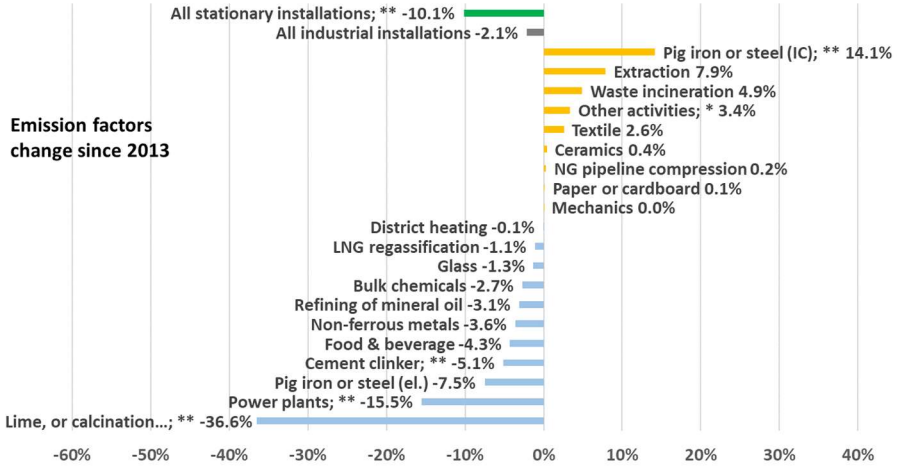


Figure 1.18 – *Percentage change from 2013 to 2020 of emission factors from fuel consumption by main activity sector. Mann-Kendall test significance: * p<0.05; ** p<0.01.*

In order to analyse the energy mix of ETS installations, fuels were combined into five categories as reported in Table 1.5.

Table 1.5 – *List of fuels used in ETS installations and fuel categories.*

Fuel category	Fuels	Fuel category	Fuels
Solid fossil fuels	Bituminous coal	***Oil and petroleum products (gaseous)***	Gas from chemical plants
	Coking coal		Refinery gas
	Anthracite		Gas from gasification of heavy fuel oil
	Lignite		Flare gas
	Coke oven coke		Gas associated to extraction
	Other solid fuels		Other gaseous fuels
Oil and petroleum products (no gaseous)	Bitumen	***Natural gas***	Natural gas
	Coal tar	***Manufactured gases***	Oxygen steel furnace gas
	Fuel oil		Blast furnace gas
	Used oil		Coke oven gas
	Gas oil and diesel oil	***Other fuels***	Solid biomass
	Liquefied petroleum gases		Liquid biomass
	Gasoline		Biogas
	Kerosene		Landfill gas
	Naphtha		Waste
	Heavy fuel oil for gasification		Tyres
	Organic solvent	***No fuels***	Process emissions by inorganic matter
	Orimulsion		
	Petroleum coke		
	Other liquid fuels		

Figure 1.19 shows the emissions trend by fuel category and the relative share of energy consumption (fossil energy and bioenergy). The picture show the decreasing share of energy by fuels with higher carbon content as solid fossil fuels and no gaseous petroleum products (from 42.1% to 19.9% from 2005 to 2020) and the corresponding increase of natural gas share (from 46.6% to 63.3%). Such fuel shift explains the emission factors reduction.

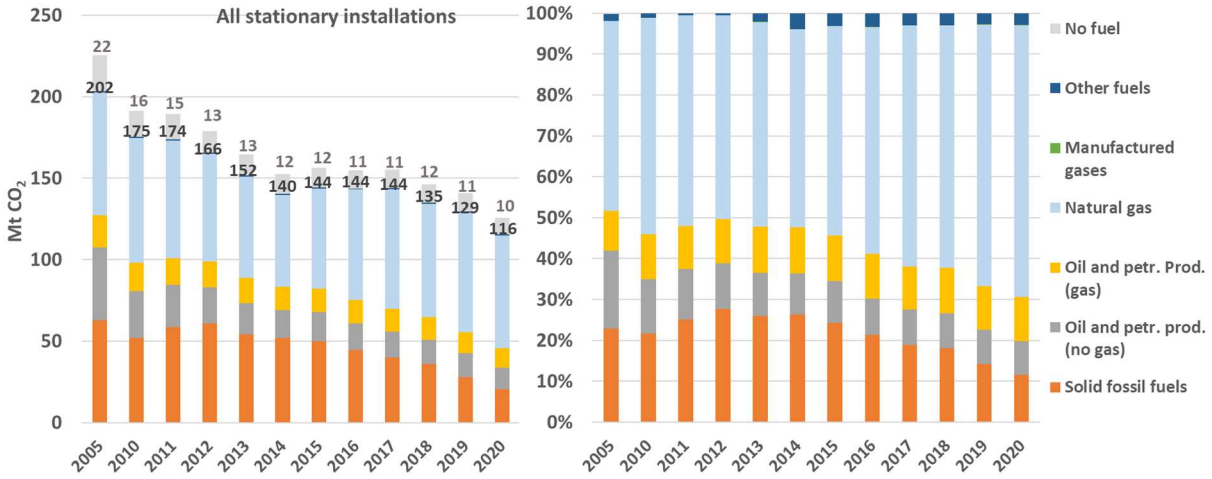


Figure 1.19 – *Trend of emissions from fuel consumption and no fuels emissions (left), energy consumption share (right) by fuel category for all ETS stationary installations.*

As already mentioned, an important role in the observed fuel shift is played by the power sector. In order to analyse the energy mix in industrial sectors, it is therefore necessary to separate power sector from the other sectors. For a detailed analysis of the power sector, please refer to ISPRA 2021[c]. The fuel mix in the sector is reported here for completeness and Figure 1.20 shows how the share of energy consumption by natural gas increased from 54.2% in 2005 to 79.2% in 2020, while the shares of solid fossil fuels and no gaseous petroleum products fell from 38.5% to 14.3%.

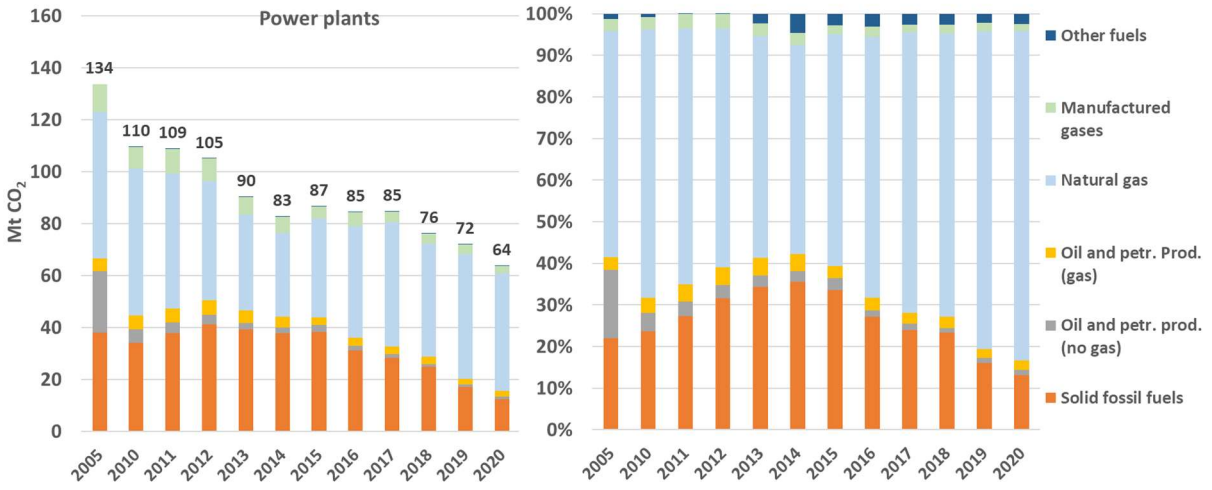


Figure 1.20 - *Trend of emissions from fuel consumption (left) and energy consumption share (right) by fuel category for power plants.*

The emissions trend for all industrial installations is shown in Figure 1.21. With regard to manufactured gases, it should be underlined that these gases are produced by the integrated cycle steel industry from solid fossil fuels, mainly coal, and are consumed in the power plants, which is why considering all stationary installations the net balance of emissions and energy consumption for these fuels is near zero while is negative taking into account the industrial installations.

Even in the industrial sectors there was a marked increasing share of natural gas, whose energy consumption raised from 32.8% to 50.8% in the period 2005-2020, and consequent decreasing of energy consumption by solid fossil fuels and manufactured gases (from 19.2% to 7.9%), as well as petroleum products other than gaseous ones (from 23.5% to 16.9%).

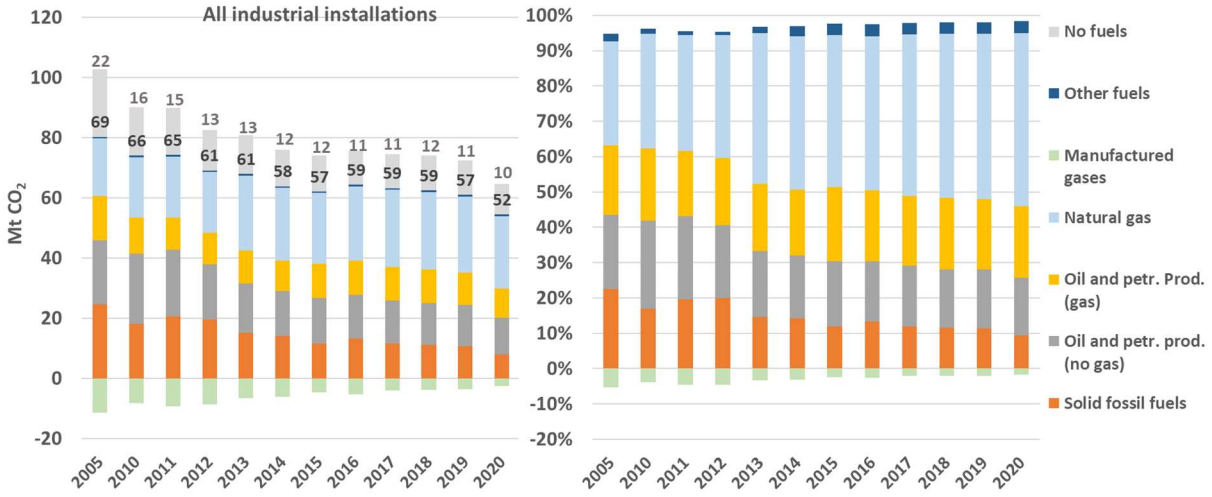


Figure 1.21 - *Trend of emissions from fuel consumption and no fuels emissions (left), energy consumption share (right) by fuel category for all industrial installations.*

The emissions by almost all fuel categories decreased since 2005, although with different trends (Table 1.6). The emissions from natural gas increased since 2005 in the industrial installations but a decreasing trend is recorded since 2013.

Table 1.6 – *Emissions by fuel category (Mt CO_2eq) for all ETS stationary installations, power plants, and industrial installations.*

Activities	Fuel category	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
All stationary installations	Solid fossil fuels	62.5	52.0	49.8	20.5	-67.2%	-62.2%
	Oil & petr. (no gaseous)	45.0	28.7	17.9	13.0	-71.1%	-31.9%
	Oil & petr. (gaseous)	19.8	17.3	14.4	12.0	-39.6%	-23.4%
	Natural gas	75.2	76.7	61.4	69.3	-7.8%	11.9%
	Manufactured gases	-0.7	0.1	0.1	0.1	-116.3%	16.6%
	Other fuels	0.6	0.7	0.7	0.7	14.8%	11.3%
	No fuels	22.4	16.0	12.0	10.2	-54.5%	-20.5%
	Total	**202.5**	**175.5**	**144.2**	**115.6**	**-42.9%**	**-23.7%**
Power plants	Solid fossil fuels	37.9	34.1	38.2	12.5	-67.1%	-68.1%
	Oil & petr. (no gaseous)	23.7	5.3	2.7	0.9	-96.0%	-64.5%
	Oil & petr. (gaseous)	5.0	5.3	3.1	2.2	-56.7%	-53.5%
	Natural gas	56.3	56.5	37.9	45.3	-19.4%	22.6%
	Manufactured gases	10.7	8.3	4.7	2.7	-74.6%	-59.6%
	Other fuels		0.1	0.2	0.1		-5.9%
	Total	**133.6**	**109.5**	**86.8**	**63.8**	**-52.3%**	**-29.4%**
All industrial installations	Solid fossil fuels	24.6	18.0	11.6	8.0	-67.4%	-46.7%
	Oil & petr. (no gaseous)	21.3	23.4	15.1	12.1	-43.4%	-26.6%
	Oil & petr. (gaseous)	14.8	12.0	11.3	9.8	-33.7%	-10.7%
	Natural gas	19.0	20.1	23.5	24.0	26.6%	-3.8%
	Manufactured gases	-11.4	-8.2	-4.6	-2.6	-77.2%	-60.8%
	Other fuels	0.6	0.7	0.5	0.6	-6.2%	16.1%
	No fuels	22.4	16.0	12.0	10.2	-54.5%	-20.5%
	Total	**68.9**	**66.0**	**57.4**	**51.9**	**-24.7%**	**-15.4%**

[a] Net consumption of manufactured gases in all installations is due to a single power plant consuming self-produced coke oven gas.

The trends of emissions by fuel and activity sector provide an insight concerning the potential to reach the emissions reduction in ETS sectors by 2030. If EU-ETS remained unchanged, the sectors

currently covered would achieve emission reductions at European level of -51% in 2030 compared to 2005 (EC, 2021[a]). According to the last Italian emission projections submitted by ISPRA to the European Commission in March 2021 pursuant to the Monitoring Mechanism Regulation, EC 525/2013 (EEA, 2021), prepared before the 'fit for 55' package proposals but reflecting the consequence of the Covid-19 pandemic, the ETS emissions projected in 2030 will be 123.0 $MtCO_2$ for the scenario with existing measures (WEM; -50.3% compared to 2005) and 95.7 $MtCO_2$ for the scenario with additional measures (WAM; -61.4% compared to 2005). The current ETS revision for the 4th phase should result in an overall emission reduction of sectors under the EU ETS of 61% by 2030 compared to 2005. Considering the 61% reduction applied to the current ETS sectors the emissions from Italian stationary installations in 2030 should be about 97 $MtCO_2$, about 26 $MtCO_2$ less than WEM scenario but about 1 $MtCO_2$ above the WAM scenario. Such figures show clearly that Italy needs additional measures set up in the National Energy and Climate Plan (Aa. Vv., 2020) to reach the new ETS target and that a crucial role will be played by power sector with the coal phase out by 2025 and the increase of renewable electricity up to 55% by 2030 from current 40%. The power sector will play a central role also in the long term strategy for reducing GHG emissions (Aa. Vv., 2021; Peschi et al., 2021).

The fuel mix is not the only factor determining the emissions trend. An important role is also played by the carbon content for each fuel concerning the specific emission factors. Table 1.7 shows how the emission factors for some fuel category, such as manufactured gases or gaseous petroleum products, as well as natural gas in power plants show significant decreasing trends since 2013.

Table 1.7 – *Emission factors by fuel category. The percentage changes in the period 2005-2020 and 2013-2020 are reported with the p significance level of Mann-Kendall test (*: p<0.05; **: p<0.01).*

	Fuel category	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
All stationary installations	Solid fossil fuels	93.0	92.8	95.6	95.2	2.4%*	0.3%
	Oil & petr. (no gaseous)	81.4	82.9	82.8	84.1	3.3%	1.0%
	Oil & petr. (gaseous)	68.6	60.3	59.9	59.2	-13.8%**	-5.8%**
	Natural gas	55.5	55.9	56.2	56.1	1.1%	-0.6%**
	Manufactured gases	92.1	41.0	44.3	46.6	-49.4%	13.7%*
	Other fuels	12.3	25.3	10.0	13.1	6.0%	-2.0%
	Total	**69.5**	**67.6**	**67.4**	**62.0**	**-10.8%****	**-10.1%****
Power plants	Solid fossil fuels	92.5	91.8	94.6	93.4	1.0%*	-0.2%
	Oil & petr. (no gaseous)	76.8	77.3	78.1	77.3	0.7%	-0.5%
	Oil & petr. (gaseous)	86.6	91.6	87.8	89.3	3.1%	-2.4%
	Natural gas	55.5	56.0	56.5	56.1	1.2%	-1.2%**
	Manufactured gases	196.0	183.4	184.5	154.9	-21.0%	-15.0%*
	Other fuels		4.1	4.7	5.2		9.9%
	Total	**71.4**	**70.0**	**72.0**	**62.5**	**-12.5%***	**-15.5%****
All industrial installations	Solid fossil fuels	93.9	94.9	99.0	98.3	4.7%	-0.2%
	Oil & petr. (no gaseous)	87.2	84.3	83.7	84.7	-2.9%	0.5%
	Oil & petr. (gaseous)	64.1	52.4	55.1	55.1	-14.2%	-0.7%
	Natural gas	55.5	55.6	55.7	56.0	0.9%**	0.3%
	Manufactured gases	183.1	189.6	199.5	172.7	-5.7%	-10.1%*
	Other fuels	24.3	42.6	15.6	19.9	-18.2%	-26.6%
	Total	**66.1**	**64.0**	**61.5**	**61.4**	**-7.1%***	**-2.1%**

[a] Net consumption of manufactured gases in all installations is due to a single power plant consuming self-produced coke oven gas.

Each activity sector is fed by specific fuel mix related both to technology and production. Figures 1.22a-1.22e show that the fuel mix can be very heterogeneous among sectors. Some sectors use prevalently a single or few fuel categories, while other sectors have greater homogeneity among fuel categories with emissions from multiple sources. The first four sectors in Figure 1.22a account for 61.4% of industrial emissions and 55.5% of energy consumption. In such sectors natural gas plays an important role only in bulk chemicals sector while there is a clear dominance of solid fossil fuels in integrated-cycle pig iron or steel sectors and petroleum products in cement clinker plants and, of course, refining of mineral oil. Greater homogeneity of the energy mix is found in the chemical sector except for solid

fossil fuels consumption. Natural gas is the dominant fuel in all other industrial sectors and in some sector covers almost all energy needs.

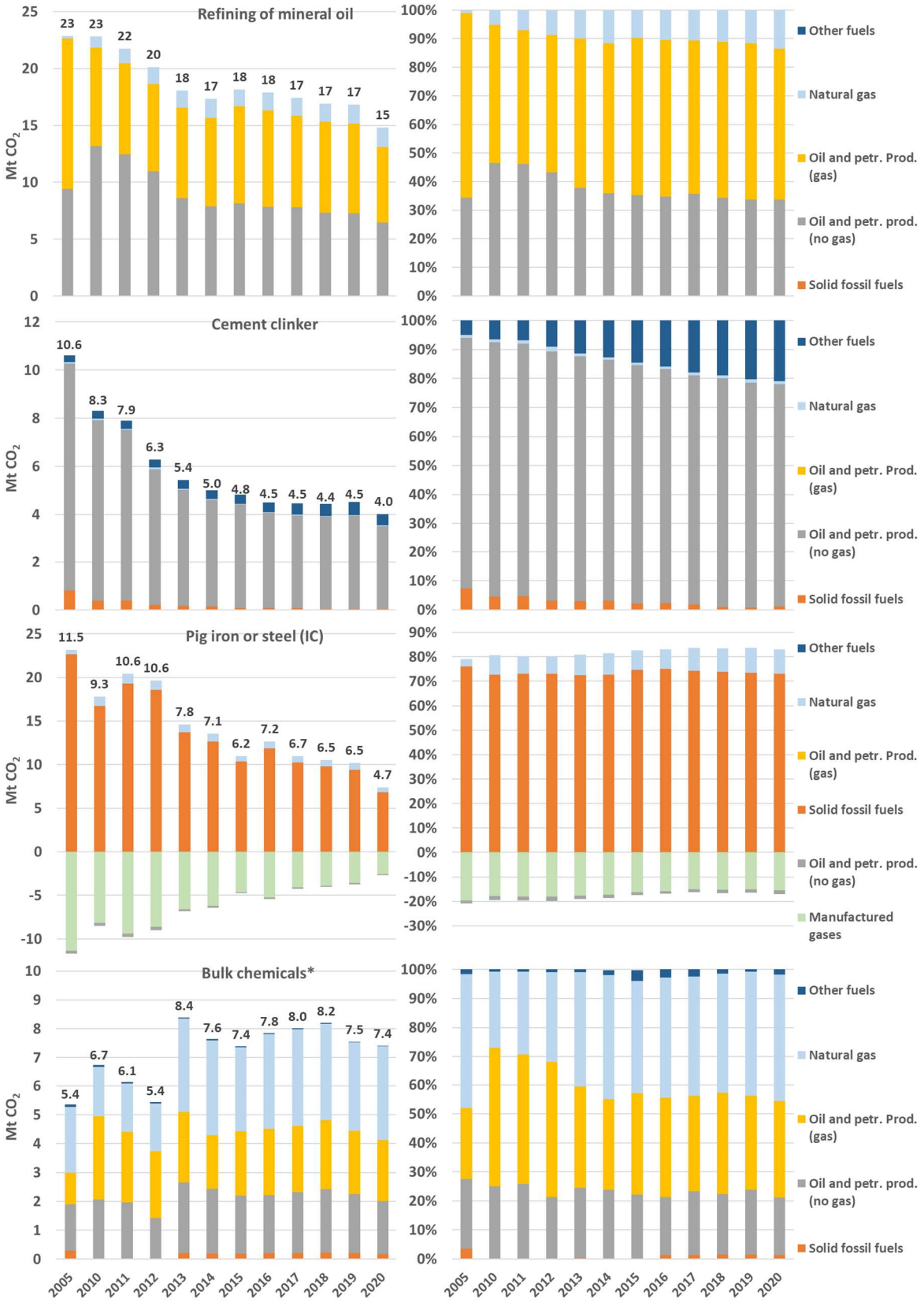


Figure 1.22a - *Trend of emissions from fuel consumption (left), energy consumption share (right) by fuel category in main activity sectors. * Sectors affected by ETS scope extension since 2013.*

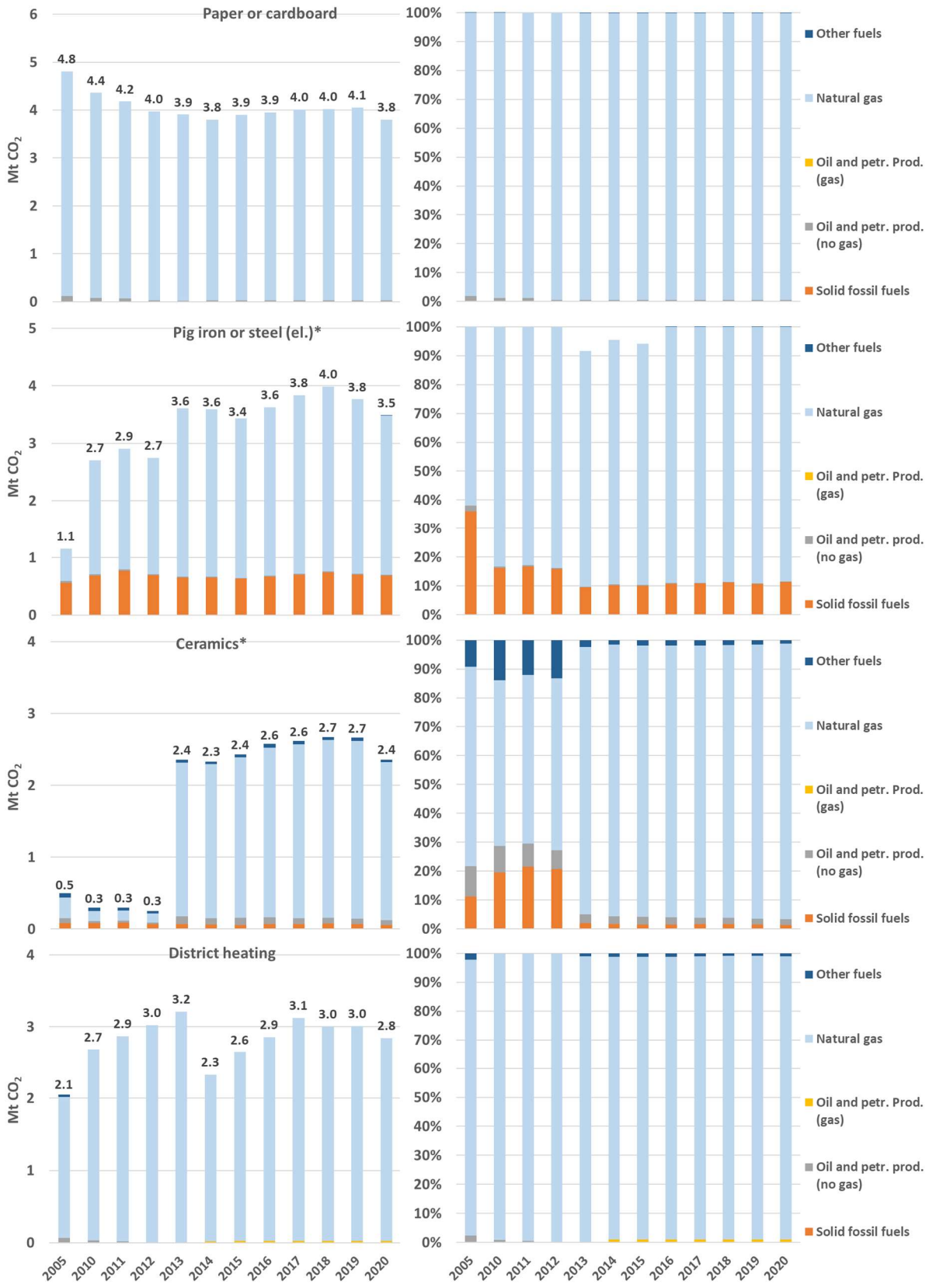


Figure 1.22b - *Trend of emissions from fuel consumption (left), energy consumption share (right) by fuel category in main activity sectors. * Sectors affected by ETS scope extension since 2013.*

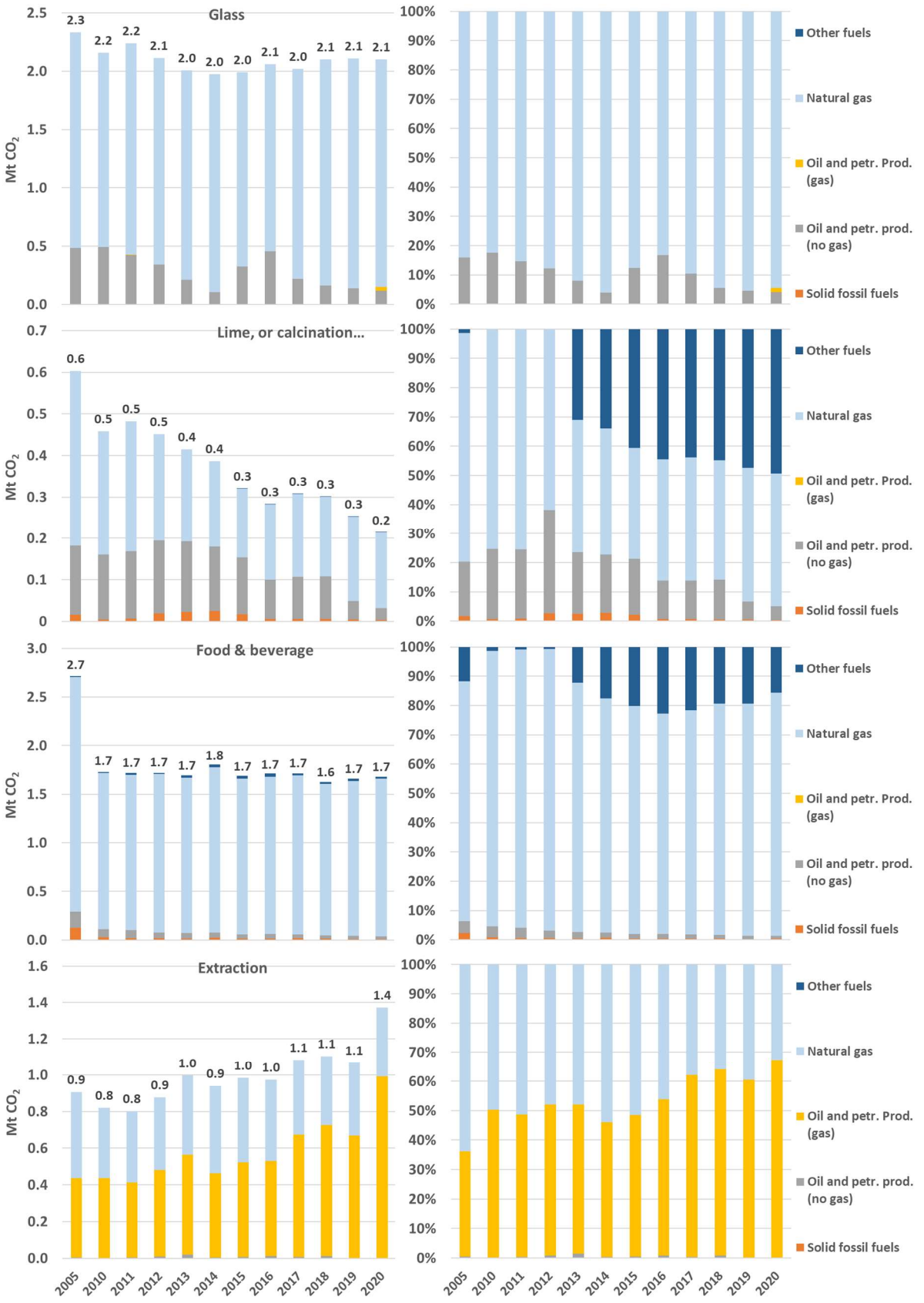


Figure 1.22c - *Trend of emissions from fuel consumption (left), energy consumption share (right) by fuel category in main activity sectors. * Sectors affected by ETS scope extension since 2013.*

Figure 1.22d - *Trend of emissions from fuel consumption (left), energy consumption share (right) by fuel category in main activity sectors. * Sectors affected by ETS scope extension since 2013.*

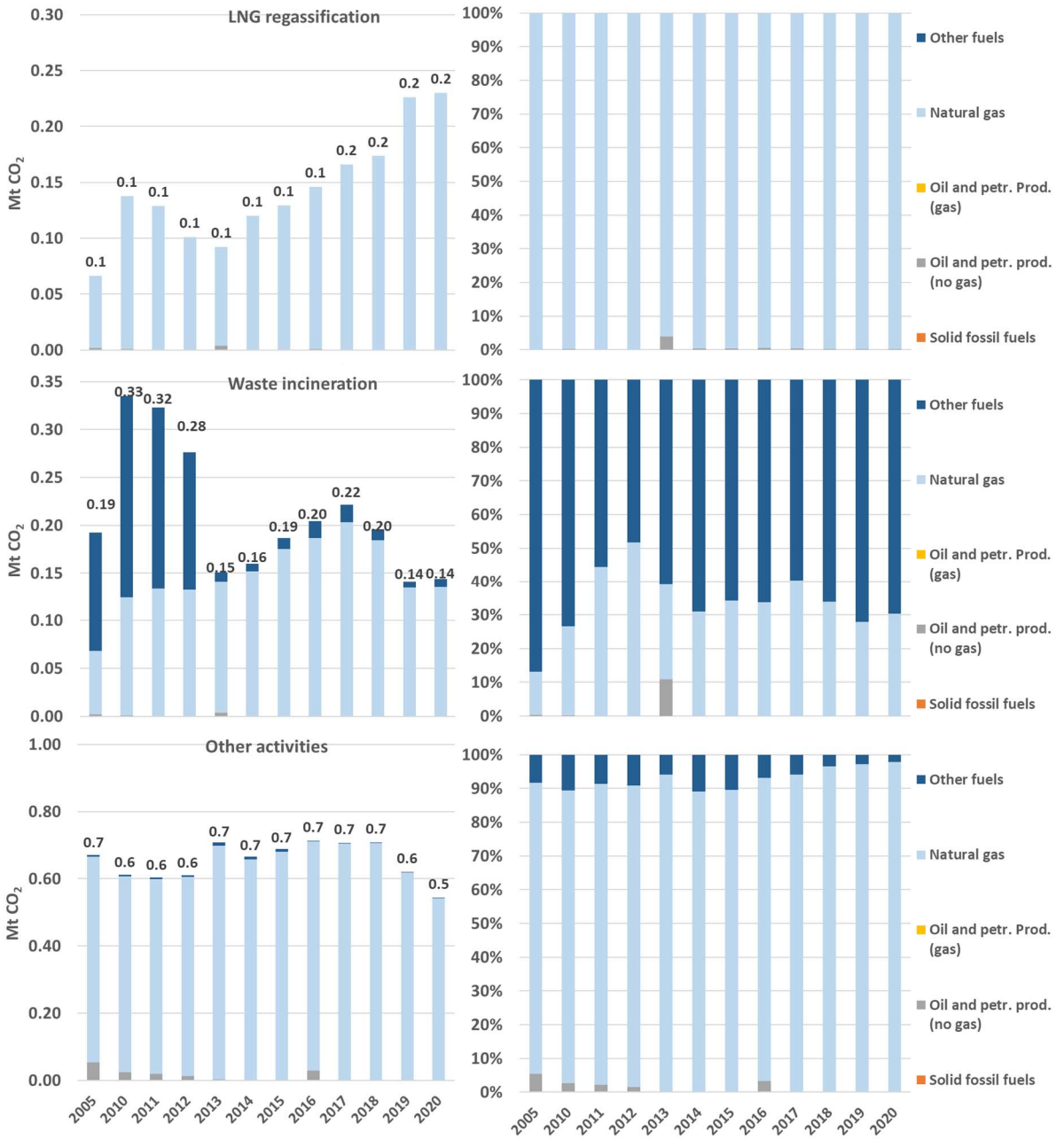


Figure 1.22e - *Trend of emissions from fuel consumption (left), energy consumption share (right) by fuel category in main activity sectors. * Sectors affected by ETS scope extension since 2013.*

The graphs shows that in some sector, as cement clinker and lime, the consumption of other fuels than fossils, mainly wastes and bioenergies, has increased significantly. In cement installations the energy consumption by such fuels increased significantly and in 2020 met 21.0% of the sector energy demand. Installations in the lime sector met 49.4% of energy needs with solid biomass, while food & beverage sector met 15.7% of the energy needs of 2020 with biomasses and wastes.

1.3 Geographical distribution of installations and emissions

The regional distribution of installations is quite heterogeneous, with higher concentration in the northern regions, especially Lombardy and Emilia Romagna. The number of installations increased sharply in the north-eastern regions since 2005, especially Emilia Romagna. On the other hand, the emissions in the southern regions, such as Apulia and Sicily, show significant share despite the lower number of installations.

Table 1.8 – *Installations number and emissions ($MtCO_2eq$) per region. The change percentage in the period 2005-2020 is also reported.*

	2005		2010		2015		2020		Δ% 2005-2020	
Regions	**N°**	**$MtCO_2eq$**	**N°**	**$MtCO_2eq$**	**N°**	**$MtCO_2eq$**	**N°**	**$MtCO_2eq$**	**N°**	**$MtCO_2eq$**
Liguria	24	11.0	23	8.8	22	4.6	18	1.6	-25.0%	-85.8%
Lombardy	191	30.0	197	24.6	200	20.3	190	20.3	-0.5%	-32.5%
Piedmont	109	10.9	115	10.5	107	9.2	101	10.2	-7.3%	-6.4%
Aosta Valley	2	0.0	1	0.1	2	0.1	3	0.1	50.0%	350.8%
North West	**326**	**51.9**	**336**	**44.1**	**331**	**34.2**	**312**	**32.1**	**-4.3%**	**-38.2%**
Emilia Romagna	107	12.7	112	11.8	183	9.8	171	11.8	59.8%	-7.0%
Friuli Venezia Giulia	29	6.6	32	6.7	32	5.7	29	3.4	0.0%	-48.7%
Trentino South Tyrol	22	0.8	24	0.9	22	0.8	20	0.7	-9.1%	-16.3%
Veneto	97	18.0	103	10.6	100	11.6	91	6.2	-6.2%	-65.3%
North East	**255**	**38.0**	**271**	**30.0**	**337**	**27.9**	**311**	**22.1**	**22.0%**	**-42.0%**
Lazio	45	15.3	50	11.2	49	13.4	45	7.0	0.0%	-53.9%
Marche	19	3.5	16	3.0	13	0.9	11	0.7	-42.1%	-78.4%
Tuscany	93	12.5	94	9.8	94	6.0	87	5.9	-6.5%	-53.0%
Umbria	17	5.3	19	3.7	24	2.3	18	2.3	5.9%	-56.5%
Centre	**174**	**36.5**	**179**	**27.7**	**180**	**22.6**	**161**	**15.9**	**-7.5%**	**-56.3%**
Abruzzo	21	2.7	22	2.6	20	1.2	19	2.0	-9.5%	-28.4%
Basilicata	9	1.5	9	1.4	10	1.6	11	1.9	22.2%	24.2%
Calabria	13	3.7	15	4.5	14	4.1	12	4.6	-7.7%	24.3%
Campania	37	3.1	79	4.7	57	2.9	48	2.2	29.7%	-28.6%
Molise	11	1.6	12	1.7	12	1.0	9	1.5	-18.2%	-1.1%
Apulia	35	42.7	44	37.0	42	31.5	37	19.2	5.7%	-55.1%
South	**126**	**55.4**	**181**	**51.9**	**155**	**42.3**	**136**	**31.5**	**7.9%**	**-43.2%**
Sardinia	18	15.7	19	13.9	18	11.3	16	10.8	-11.1%	-31.4%
Sicily	43	28.4	43	23.9	40	17.9	38	13.6	-11.6%	-51.9%
Islands	**61**	**44.1**	**62**	**37.8**	**58**	**29.2**	**54**	**24.4**	**-11.5%**	**-44.6%**
Italy	**942**	**226.0**	**1,029**	**191.5**	**1,061**	**156.2**	**974**	**126.0**	**3.4%**	**-44.2%**

The maps in Figure 1.23 show the slight increase of installations number since 2005 in contrast with the relevant decrease of emissions. Only few regions represent exception to this trend, as Basilicata and Calabria.

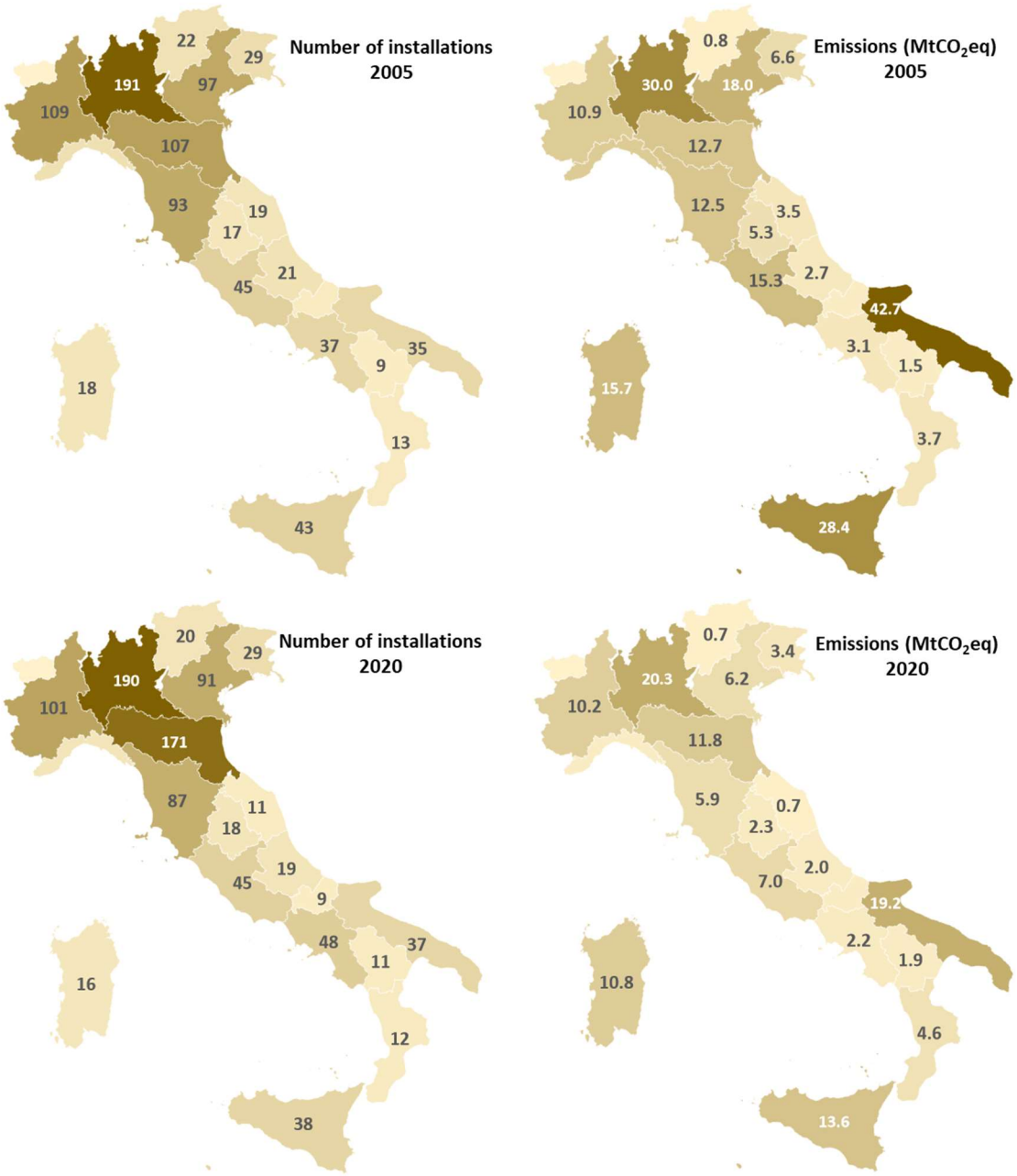


Figure 1.23 – *Regional distribution of all stationary installations number and emissions in 2005 and 2020.*

A better understanding about geographical distribution of installations and emissions is possible considering power plants and industrial installations separately. As for power plants (Figure 1.24), the southern regions still in 2020 have higher share of emissions despite the lower number of installations than that recorded in the northern regions. The number of power plants compared to all installations is 13.3% in 2020, while the emissions account for 50.6%, with Apulia and Lombardy taking respectively 9.5% and 8.8%. South and North West have the highest share of emissions from power plants accounting for respectively 31.5% and 25.2% of 2020 emissions. In the remaining macro areas, the emissions share ranges from 13.5% in the North East to 15.6% in the Islands. At national level the number of power plants since 2005 decreased by 5.1% while the emissions decreased by 52.5%.

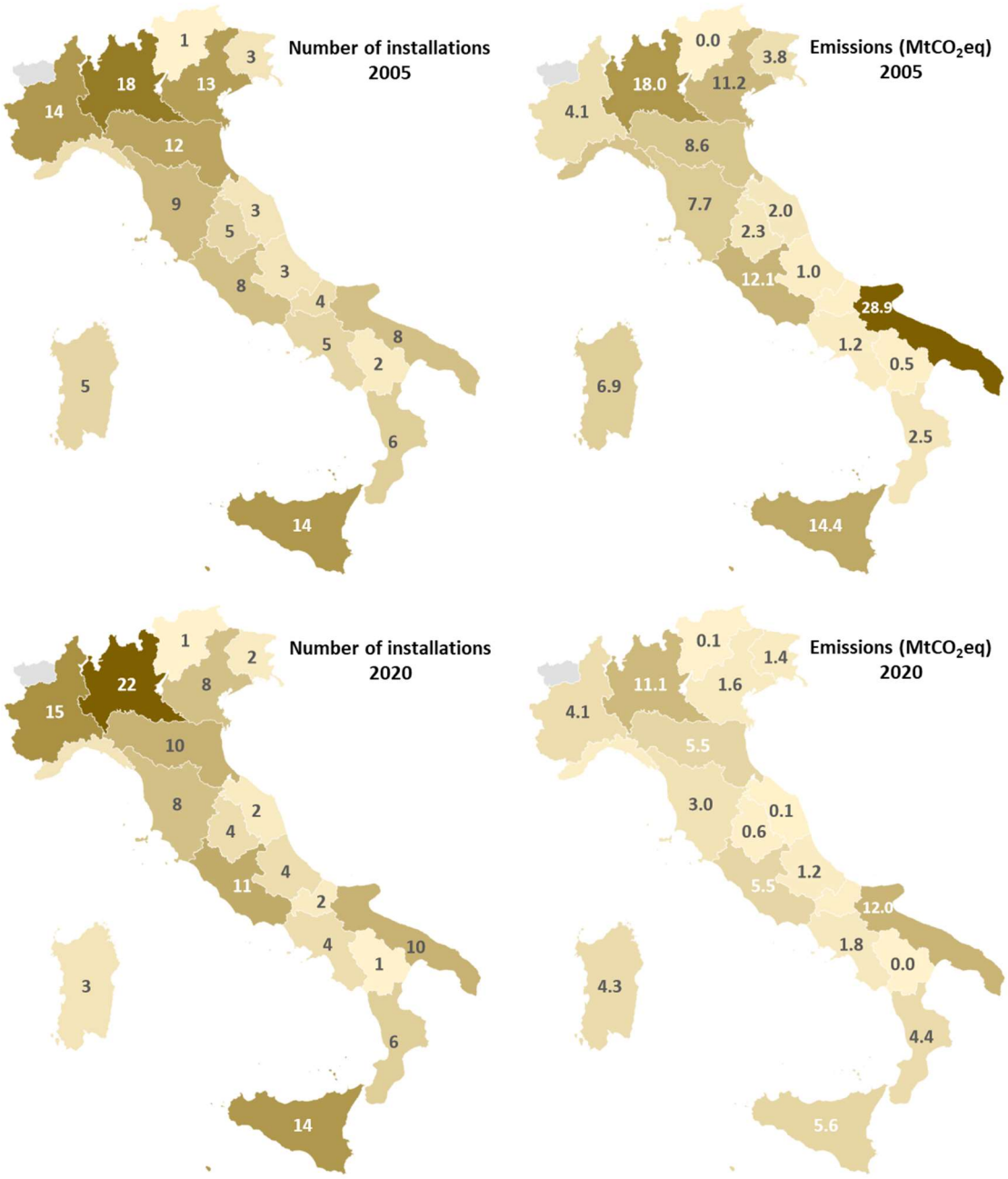


Figure 1.24 – *Regional distribution of power plants number and emissions in 2005 and 2020.*

Industrial installations account for 86.7% of all installations and 49.4% of total ETS emissions. The northern regions recorded the highest number of installations, especially in Lombardy, Emilia Romagna, Piedmont and Veneto (Figure 1.25) despite a quite similar share of emissions with southern regions and islands (23.4% *vs* 20.5%). At national level since 2005 to 2020 there was 4.8% increase of industrial installation while the emissions decreased by 32%. In North East and South regions, the number of installations increased by 28.3% and 11.2% respectively. Such increases are also due to the ETS revision that enlarged the ETS scope since 2013 to industrial installation not previously considered.

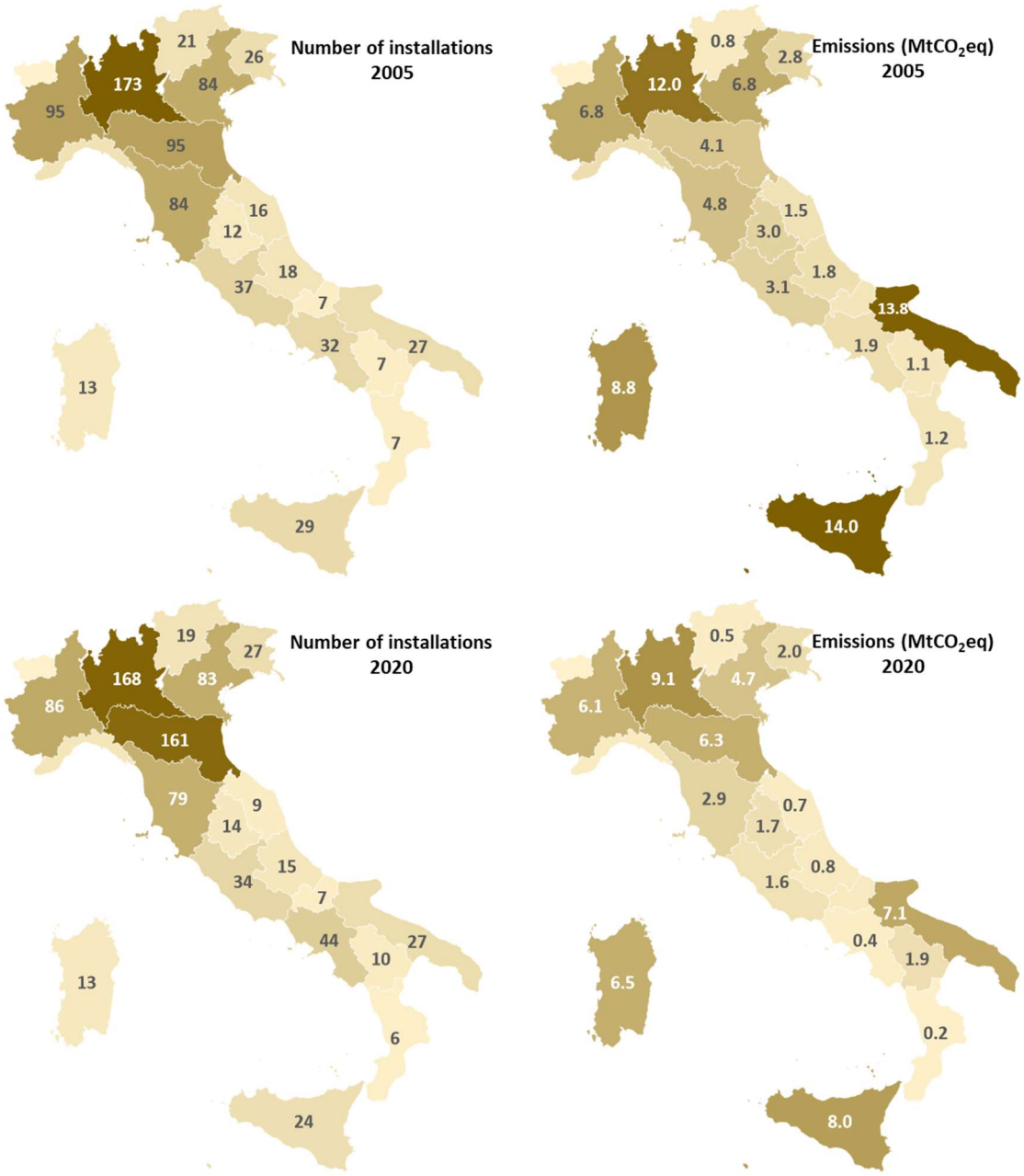


Figure 1.25 – *Regional distribution of industrial installations number and emissions in 2005 and 2020.*

Table 1.9 summarizes the number of plants, emissions, and emissions intensity for 2005 and 2020. Over time, the intensity per plant decreased by 46.1% at national level, with higher reductions in the North-East and Centre. In the southern and island regions, the intensities are highest, with values ranging from 1.8 to 3.5 times the national average in 2020. The southern regions and the islands registered the highest emissive intensities both for power plants and industrial installations due to plants powered by solid fossil fuels, mainly in Apulia, and refinery of mineral oil installations, mainly in Sicily.

Table 1.9 – *Installations number, emissions ($MtCO_2eq$), and plant emissions intensity per geographical macro areas. The percentage of change in the period 2005-2020 are also reported.*

	2005		2020		2005	2020	Δ% 2005-2020		
	N°	$MtCO_2eq$	N°	$MtCO_2eq$	$ktCO_2eq$ x plant		N°	$MtCO_2eq$	Intensity
All installations									
North West	326	51.9	312	32.1	159.3	102.9	-4.3%	-38.2%	-35.4%
North East	255	38.0	311	22.1	149.2	71.0	22.0%	-42.0%	-52.4%
Centre	174	36.5	161	15.9	209.7	99.0	-7.5%	-56.3%	-52.8%
South	126	55.4	136	31.5	439.6	231.4	7.9%	-43.2%	-47.4%
Islands	61	44.1	54	24.4	723.5	452.5	-11.5%	-44.6%	-37.5%
Italy	**942**	**226.0**	**974**	**126.0**	**239.9**	**129.4**	**3.4%**	**-44.2%**	**-46.1%**
Power plants									
North West	36	31.1	40	16.1	864.9	402.7	11.1%	-48.3%	-53.4%
North East	29	23.6	21	8.6	813.7	408.7	-27.6%	-63.6%	-49.8%
Centre	25	24.1	25	9.1	962.0	362.6	0.0%	-62.3%	-62.3%
South	28	34.4	27	20.1	1229.4	744.2	-3.6%	-41.6%	-39.5%
Islands	19	21.3	17	10.0	1119.0	585.8	-10.5%	-53.2%	-47.7%
Italy	**137**	**134.5**	**130**	**63.8**	**981.5**	**490.8**	**-5.1%**	**-52.5%**	**-50.0%**
Industrial installations									
North West	290	20.8	272	16.0	71.7	58.8	-6.2%	-23.1%	-18.0%
North East	226	14.4	290	13.5	63.9	46.5	28.3%	-6.6%	-27.2%
Centre	149	12.4	136	6.9	83.5	50.6	-8.7%	-44.7%	-39.4%
South	98	21.0	109	11.4	213.9	104.3	11.2%	-45.8%	-51.2%
Islands	42	22.9	37	14.5	544.5	391.3	-11.9%	-36.7%	-28.1%
Italy	**805**	**91.5**	**844**	**62.2**	**113.7**	**73.7**	**4.8%**	**-32.0%**	**-35.2%**

Figures 1.26 and 1.27 show the increasing share of emissions by natural gas in 2020 compared to 2005 both in power plants and industrial installations with consequent reduction of emissions by solid fossil fuels and oil or petroleum products in almost all macro areas. Some exceptions concern power plants for the entry into operation since 2009 of the Torvaldaliga plant in Lazio (Centre), and increasing activity of power plants fed by solid fuels in Veneto (North East) and Apulia (South). As for the Islands an increasing activity has been recorded in Sardinia power plants in 2020.

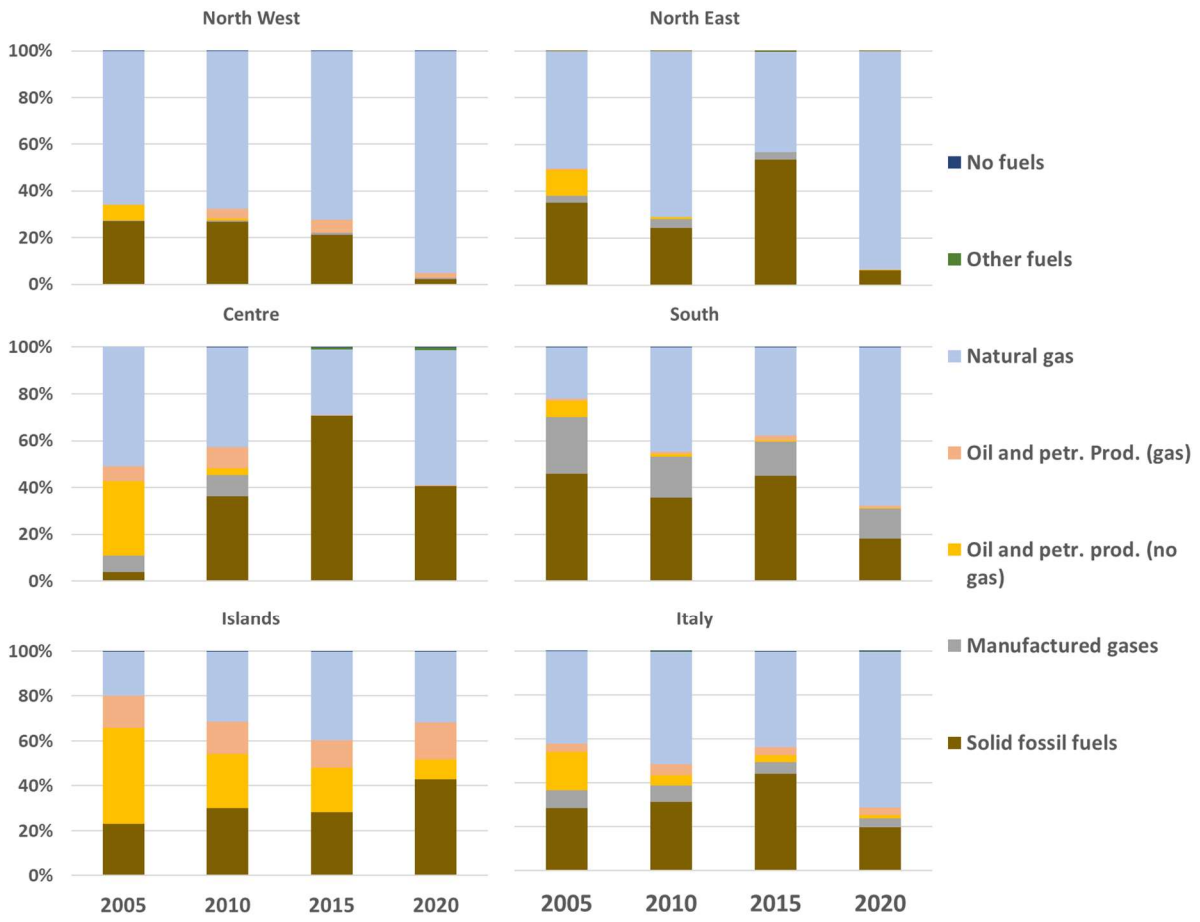


Figure 1.26 – *Share of emissions by power plants for fuel category in macro areas and at national level.*

In the industrial plants the reduction of emissions by solid fossil fuels and oil or petroleum products is rather marked in every macro area, only in the southern regions there is a quite high share of emissions by solid fossil fuels as wells as the significant share of emissions by petroleum products in the Islands because of the presence of the pig iron installation in Apulia and the main refineries of mineral oil in Sardinia and Sicily.

Emissions from oil and no gaseous petroleum products show considerable reductions in all regions with few exceptions. The largest reductions are recorded for the power plants whose reduction compared to 2005 is near 100% in many regions and 96% at national level. As for industry the overall reduction of emissions from oil and no gaseous petroleum products is by 43.4%, with southern and central areas showing higher reductions: 75.2% and 68.4% respectively.

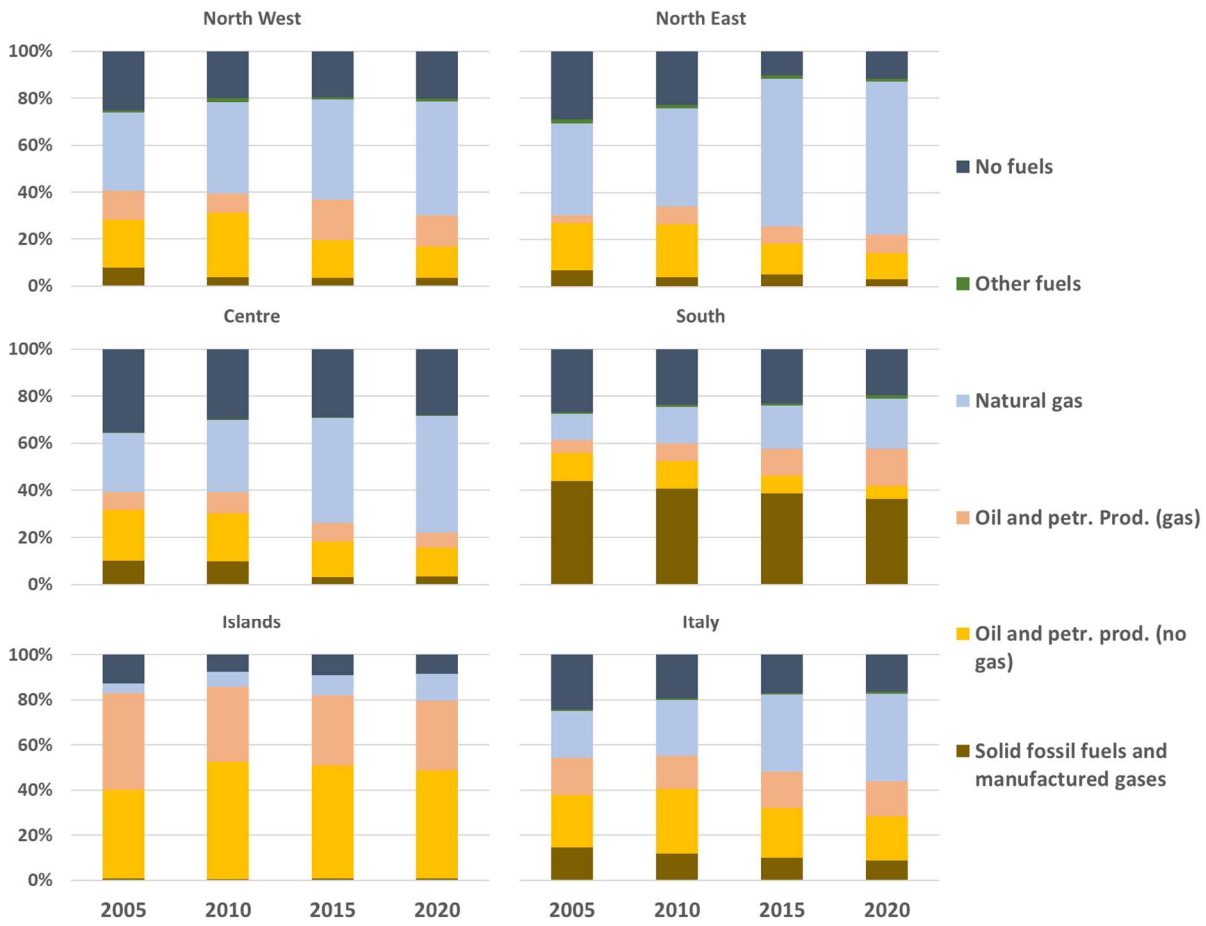


Figure 1.27 – *Share of emissions by industrial plants for fuel category in macro areas and at national level.*

The following maps (Figures 1.28-1.29) illustrate the distribution by province of the emissions from power plants and industrial installations in 2005 and 2020. The colour scale has been set to the same minimum-maximum range of both maps to highlight the change of emission class in the provinces. The maps show how the provinces shift to lighter colour from 2005 to 2020 with emissions reduction. Such shift is particularly evident in the provinces that are emission hotspots, as Brindisi for power plants and Taranto for industrial installations.

Considering emissions both from power plants and industrial emissions the top five provinces are Taranto, Syracuse, Brindisi, Cagliari, and Rome with emissions from 9.3 to 5.7 $MtCO_2eq$ in 2020 and represent 29.1% of total ETS emissions. In 2005 the five provinces had emissions ranging from 22.2 to 7.6 $MtCO_2eq$ and represented 30.7% of total ETS emissions.

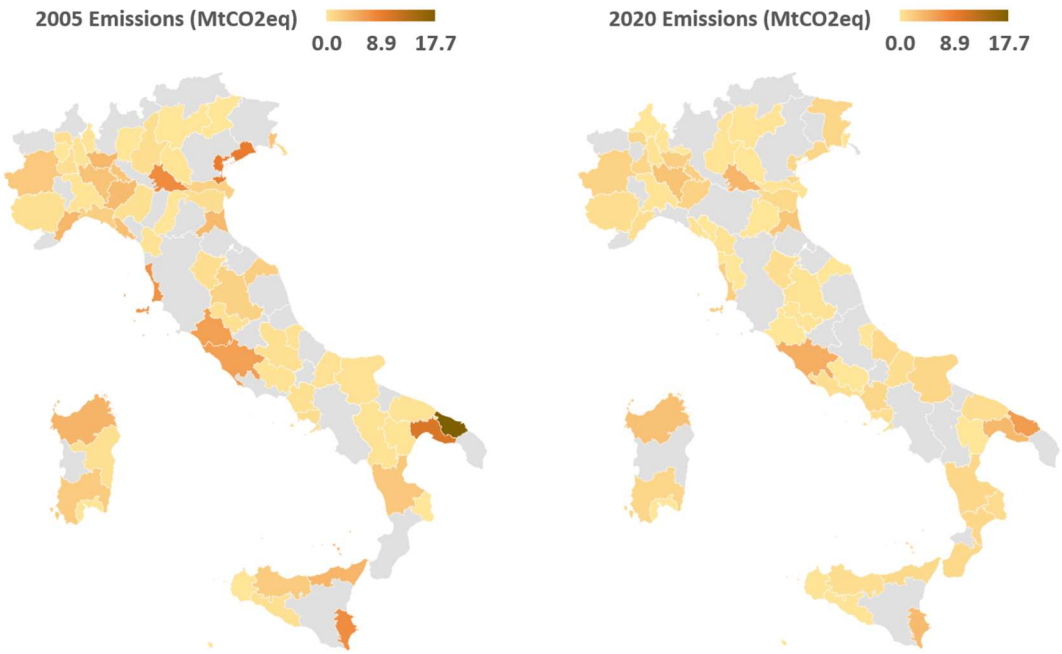


Figure 1.28 – *Emissions ($MtCO_2eq$) by power plants per province in 2005 and 2020.*

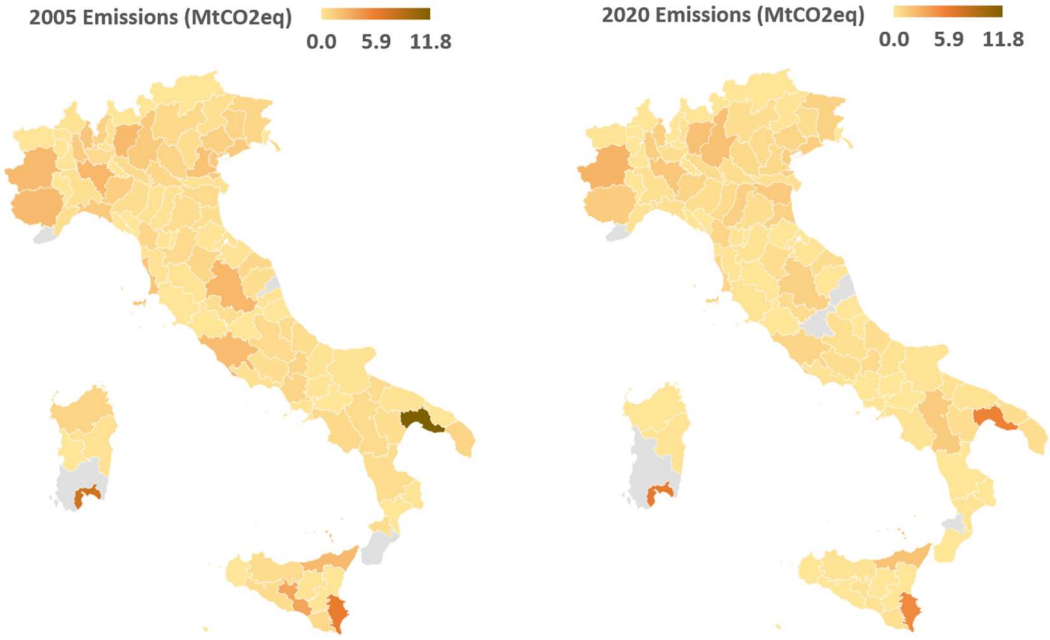


Figure 1.29 – *Emissions ($MtCO_2eq$) by industrial installations per province in 2005 and 2020.*

The following table shows in detail the regional distribution of emissions by main activity sector in 2020.

Table 1.10 – *Emissions ($ktCO_2eq$) per regions by main activity sector in 2020. The sectors accounting for at least 98% of the 2020 emissions are explicitly reported (A-N), the remaining sectors are aggregated.*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Italy
Regions	**kt CO_2eq**															
Liguria	855.4	230.1		53.2		55.9	31.3	20.4		228.1				4.2	84.7	**1,563.4**
Lombardy	11,145.3	1,469.6	2,769.7	717.9		1,824.8	211.4	199.8	214.2	348.2	265.5	584.4		53.5	467.8	**20,272.0**
Piedmont	4,105.5	926.6	781.3	431.1		154.3	346.3	2,318.1	59.9	156.2	364.3	139.3	28.3	214.5	131.9	**10,157.6**
Aosta Valley						91.5		6.0							21.7	**119.3**
North West	**16,106.2**	**2,626.3**	**3,551.0**	**1,202.2**		**2,126.6**	**588.9**	**2,544.3**	**274.0**	**732.6**	**629.9**	**723.6**	**28.3**	**272.1**	**706.1**	**32,112.2**
Emilia Romagna	5,462.7	25.1	830.4	1,835.9		183.6	110.2	174.8	1,935.5	111.7	647.3	3.0	52.0	165.7	253.7	**11,791.5**
Friuli Venezia Giulia	1,386.0		348.7		160.2	565.0	408.3			201.4				4.9	288.6	**3,363.0**
Trentino South Tyrol	143.8			104.8		50.7	255.2	64.0		56.8					2.6	**677.9**
Veneto	1,590.0	325.3	656.1	781.3		517.7	707.9	40.4	103.2	650.9	203.2	441.5		41.1	183.2	**6,241.8**
North East	**8,582.5**	**350.4**	**1,835.1**	**2,722.0**	**160.2**	**1,317.0**	**1,481.5**	**279.2**	**2,038.7**	**1,020.8**	**850.5**	**444.6**	**52.0**	**211.6**	**728.1**	**22,074.1**
Lazio	5,461.6		808.6	92.7			342.6		50.0	64.8	29.7	59.8		10.4	107.6	**7,027.7**
Marche	81.9	358.1					131.8						114.9		58.0	**744.7**
Tuscany	2,957.8	340.7	364.3	546.5	37.7	42.5	1,057.4		52.1	255.3	15.9			36.6	167.6	**5,874.5**
Umbria	564.2		942.1			330.3	10.6		169.9	108.1		168.7		0.0	3.8	**2,297.6**
Centre	**9,065.4**	**698.8**	**2,114.9**	**639.3**	**37.7**	**372.7**	**1,542.5**		**272.0**	**428.1**	**45.6**	**228.5**	**114.9**	**47.0**	**337.1**	**15,944.5**
Abruzzo	1,156.4		139.4	16.9			168.1		68.3	188.9				175.2	53.9	**1,967.0**
Basilicata	17.1		662.3			48.7	5.4		58.4		4.2		1,049.0	73.0	0.0	**1,918.1**
Calabria	4,377.6		133.8						33.9			10.1	47.2		12.2	**4,614.8**
Campania	1,809.3						81.4	7.2		23.8	124.3	70.5		38.4	93.0	**2,247.9**
Molise	700.3		612.5	24.8					23.7			46.4	99.4	5.4	25.0	**1,537.4**
Apulia	12,033.3	637.3	694.3	482.0	4,834.1					258.4	96.5	118.4		19.1	6.9	**19,180.4**
South	**20,094.0**	**637.3**	**2,242.2**	**523.7**	**4,834.1**	**48.7**	**254.9**	**7.2**	**184.3**	**471.1**	**225.0**	**245.4**	**1,195.6**	**311.0**	**191.0**	**31,465.5**
Sardinia	4,324.0	5,772.3	317.3	69.8			5.4		22.8		4.5	26.6			245.5	**10,788.2**
Sicily	5,633.9	5,136.8	1,002.6	1,715.6		44.9	4.1		11.7	21.0		29.5	20.0		28.5	**13,648.5**
Islands	**9,957.8**	**10,909.1**	**1,319.9**	**1,785.5**		**44.9**	**9.4**		**34.5**	**21.0**	**4.5**	**56.1**	**20.0**		**273.9**	**24,436.7**
Italy	**63,806.0**	**15,221.9**	**11,063.1**	**6,872.7**	**5,032.0**	**3,910.0**	**3,877.2**	**2,830.7**	**2,803.5**	**2,673.6**	**1,755.5**	**1,698.2**	**1,410.8**	**841.7**	**2,236.2**	**126,033.0**

A: Power plants; **B**: Refining of mineral oil; **C**: Cement clinker; **D**: Bulk chemicals; **E**: Pig iron or steel (IC); **F**: Pig iron or steel (el.); **G**: Paper or cardboard; H: District heating; I: Ceramics; **J**: Glass; **K**: Food & beverage; **L**: Lime, or calcination…; **M**: Extraction; N: Mechanics; **O**: Non-ferrous metals, NG pipeline compression, Other activities; LNG regassification, Waste incineration, Textile.

Table 1.11 shows that the highest emission factors for fuel consumption (t CO_2eq/TJ) in 2020 have been recorded in the Islands and Southern regions. These values are due to the presence of plants with high intensity and substantial consumption of solid fossil fuels and oil product both in the power sector and in the industrial sectors. The data show that the decrease in the emission factors of the ETS in 2020 compared to 2005 affects almost all areas. Industrial plants show a decrease in emission factors with exception of Centre and South areas.

Table 1.11 – *Emission factors by main sector and fuel consumption (t CO_2eq/TJ) per macro area.*

	Macro area	2005	2010	2015	2020	Δ% 2005/2020
All stationary installations	North West	63.2	62.4	60.4	57.0	-9.8%
	North East	65.5	61.7	62.9	55.0	-16.0%
	Centre	65.4	70.5	72.9	63.7	-2.6%
	South	78.9	72.4	73.1	65.6	-16.9%
	Islands	75.1	71.1	69.8	71.9	-4.3%
	Italy	**69.6**	**67.6**	**67.4**	**62.0**	**-10.8%**
Power plants	North West	63.0	63.6	63.2	56.7	-10.1%
	North East	67.0	62.6	69.1	53.4	-20.3%
	Centre	67.4	75.3	78.2	65.7	-2.5%
	South	86.8	75.7	77.4	65.3	-24.7%
	Islands	75.9	73.4	70.7	76.5	0.9%
	Italy	**71.4**	**70.0**	**72.0**	**62.5**	**-12.5%**
All industrial installations	North West	63.5	60.5	57.4	57.4	-9.5%
	North East	62.5	60.2	56.8	56.3	-9.9%
	Centre	60.0	61.3	61.8	60.3	0.5%
	South	65.7	65.5	63.6	66.1	0.6%
	Islands	74.2	69.3	69.0	68.7	-7.4%
	Italy	**66.2**	**64.0**	**61.5**	**61.4**	**-7.2%**

Figures 1.30-1.31 provide an overview of the temporal variation of emission factors at provincial level. The average emission factor by province depends on the different mix of sectors and fuels. The same scale of colour has been set with the lowest and highest factors recorded in power sector and industry. Maps illustrate the reduction of emission factors in most provinces. The average emission factors for power plants and industrial installations decreased by 12.5% and 7.2% respectively from 2005 to 2020 mainly due to the increasing share of natural gas in the fuel mix.

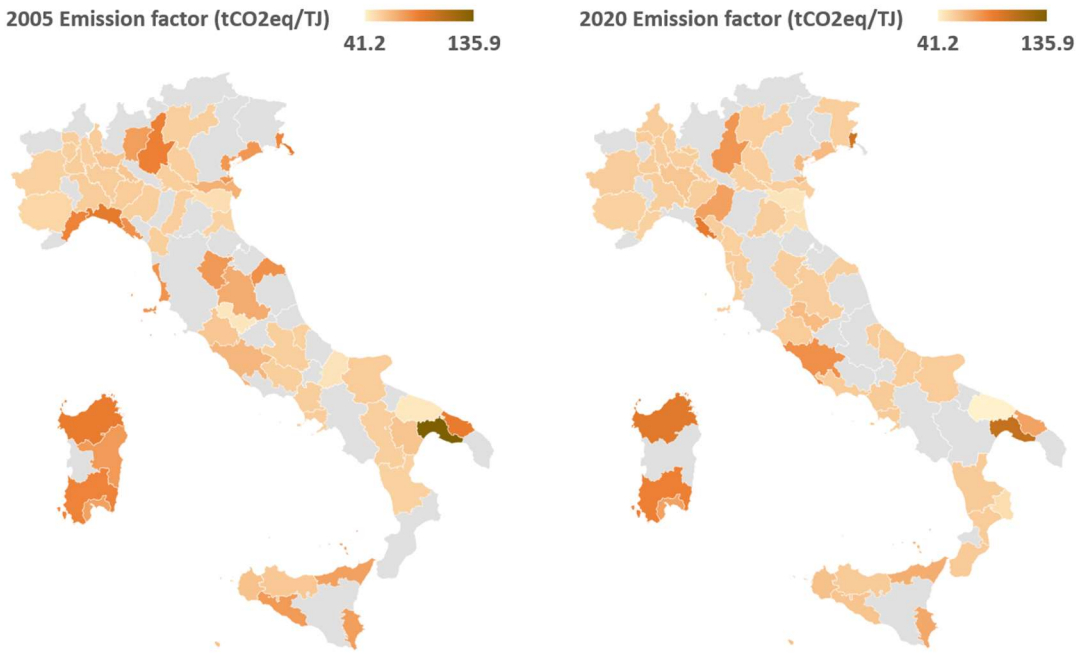


Figure 1.30 – *Average emission factors (t CO_2eq/TJ) by province for power plants in 2005 and 2020*

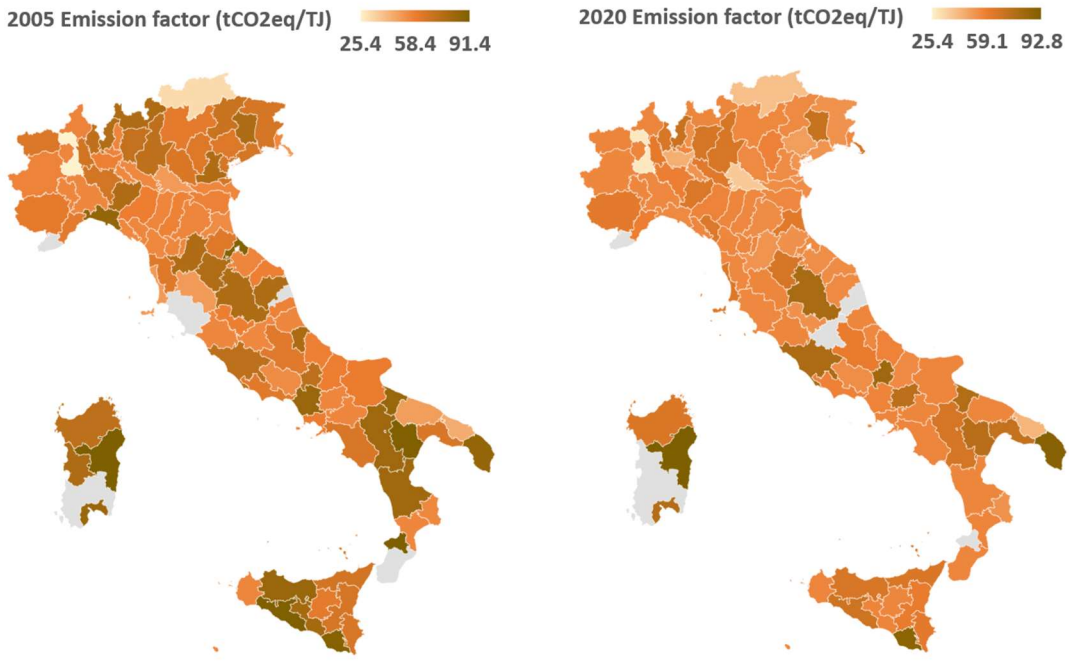


Figure 1.31 – *Average emission factors (t CO_2eq/TJ) by province for industrial installations in 2005 and 2020.*

2 EU ETS IN THE BIGGEST COUNTRIES

2.1 Source of data and methodological notes

The data used for the analysis are published by the European Environment Agency (EEA) which issues the database with data from *European Union Transaction Log* (EUTL). The EUTL is the central transaction log, run by the European Commission, which checks and records all transactions taking place within the European trading system.

The EEA database (version 44) was downloaded on 1st September, 2021 from the URL: https://www.eea.europa.eu/data-and-maps/data/european-union-emissions-trading-scheme-16

The database contains data extracted from EUTL on 1st July 2021. The data on verified emissions, allocated allowances and surrendered units for more than 15,000 stationary installations and 1,500 aircraft operators are disaggregated by country, main activity sector and year. The EEA data viewer (EEA, 2019) also provides the number of plants per verified emissions size (https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1). Free allocated allowances are provided by main activity sector, while allowances auctioned or sold (EUAs and EUAAs) are available at aggregate level for all stationary installations. The surrendered units are provided by main activity sector but without distinction whether free or sold/auctioned. Table 2.1 reports the list of activity sectors used for the analyses which is the same as in the EEA database. The classification is less detailed than that used in the analysis of Italian data but ensures the comparability of the different sectors among European countries.

Table 2.1 – *List of main activity sectors in the EEA database.*

Code and name in EEA database	Name in this report
20-99 All stationary installations	All stationary installations
20 Combustion of fuels	Combustion of fuels
21-99 All industrial installations (excl. combustion)	All industrial installations
21 Refining of mineral oil	Refining of mineral oil
22 Production of coke	Coke
23 Metal ore roasting or sintering	Metal ore roasting or sint.
24 Production of pig iron or steel	Pig iron or steel
25 Production or processing of ferrous metals	Ferrous metals
26 Production of primary aluminium	Primary aluminium
27 Production of secondary aluminium	Secondary aluminium
28 Production or processing of non-ferrous metals	Non-ferrous metals
29 Production of cement clinker	Cement clinker
30 Production of lime, or calcination of dolomite/magnesite	Lime, or calcination…
31 Manufacture of glass	Glass
32 Manufacture of ceramics	Ceramics
33 Manufacture of mineral wool	Mineral wool
34 Production or processing of gypsum or plasterboard	Gypsum or plasterboard
35 Production of pulp	Pulp
36 Production of paper or cardboard	Paper or cardboard
37 Production of carbon black	Carbon black
38 Production of nitric acid	Nitric acid
39 Production of adipic acid	Adipic acid
40 Production of glyoxal and glyoxylic acid	Glyoxal and glyoxylic acid
41 Production of ammonia	Ammonia
42 Production of bulk chemicals	Bulk chemicals
43 Production of hydrogen and synthesis gas	Hydrogen and synth. gas
44 Production of soda ash and sodium bicarbonate	Soda ash and sodium bic.
45 Capture of greenhouse gases under Directive 2009/31/EC	Capture of GHG
99 Other activity opted-in under Art. 24	Other activity opted-in

Combustion of fuels category accounts for the majority of stationary installations, both in terms of number of plants and emissions. Emissions are mainly due to the generation of electricity and heat. The free allocated allowances for such installations after 2013 are only due to heat generation. The comparison of EEA sector classification with Italian one (see Annex) reveals that combustion of fuels category in EEA data includes also plants belonging to the industrial installations. In particular, they are small emitting plants that produce electricity and heat for their industrial activities.

Based on the data reported in the European Commission's report on the functioning of the European carbon market (EC, 2020[a]) it can be estimated that from 2011 to 2018 emissions from industrial installations are about 10% of the emissions reported in the EEA database for combustion of fuels category. The European Commission's report provides the verified emissions from the production of electricity and heat and from industrial installations. The EEA database does not provide additional specifications for combustion of fuels category.

The EEA database also provides for each country estimates of the pre-2013 emissions and allowances to reflect current ETS scope following the legislation revision with extension of the ETS scope for phase 3. Such estimates are available at country level only for all stationary installations. Any sectoral analysis cannot consider such estimates.

2.2 ETS emissions from stationary installations

Currently, the EU ETS involves 31 European countries, the 28 EU28 Member States (the effective exit of the United Kingdom from the European Union took place on 31 December 2020) plus Norway, Iceland and Lichtenstein. Of the 28 Member States, 25 have joined the ETS since the first year (2005), while Bulgaria and Romania have joined in 2007, Croatia in 2013, Norway in 2008, Iceland and Lichtenstein in 2013.

ETS emissions amount to 1,355 $MtCO_2eq$ in 2020 (-42.8% compared to 2005 and -29% compared to 2013). The emissions reductions since 2005 for EU28 and EU27 are respectively 43.2% and 40.7% (29.3% and 26.1% since 2013). It must be reminded that in 2020 all activities were affected by lockdown due to SARS-CoV-2 pandemic.

ETS emissions share in total GHG emissions in 2019 ranges from 57.7% for Estonia to 13.9% for Luxembourg (Figure 2.1). The share for EU28 decreased from 44.7% in 2005 to 37% in 2019. The Netherlands and Sweden are the only countries with increase of the ETS emissions share (from 43.1% to 46.4% in the Netherlands, from 35.2% to 36.9% in Sweden).

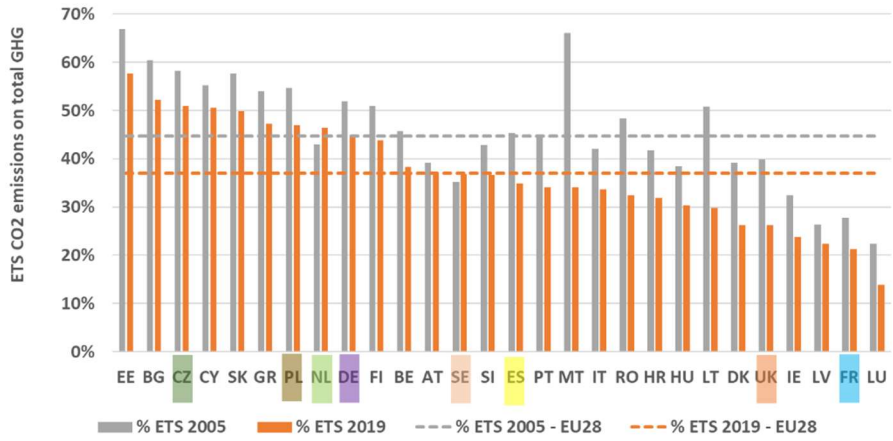


Figure 2.1 *–ETS emissions share in total GHG emissions in 2005 and 2019. Countries in descending order of 2019 ETS emissions share.*

The report focuses on the ETS data from the EU Member States which in 2019 account for more than 3% of EU28 GHG emissions or more than 3% of EU28 GDP. The criteria to select the countries

have been defined in ISPRA 2021[d]. As the quoted report focused on decarbonization and efficiency indicators, this report stands in thematic continuity concerning the comparison of ETS data among the biggest European countries.

The Member States examined (France, Germany, Italy, the Netherlands, Poland, Spain, Czechia, Sweden, and the United Kingdom) represent 77.9% of the EU28 population (74.6% w/o UK in EU27) in 2020. As for GHG emissions, they account for 78.2% of EU28 emissions (75.5% w/o UK in EU27) in 2019, while GDP (chain linked volumes, reference year 2015) represents 82.4% of EU28 GDP (78.7% w/o UK in EU27).

Figure 2.2 shows the ETS verified emissions with countries in descending order of 2020 values. The top four ETS emitting countries (Germany, Poland, Italy and the United Kingdom) account for more than 50% of total ETS emissions (53.1% in 2005 and 53.4% in 2020). Such share has not changed significantly since 2005, although the relative constancy is the result of the increasing share of Germany and Poland and the decreasing share of Italy and the United Kingdom.

The top eight ETS emitting countries are responsible for more than 75% of total ETS emissions (75.5% in 2020). Considering also ETS emissions from Sweden the share rises to 76.7%. The emissions by activity sector and related free allocated allowances will be analysed for such countries. The sectoral analysis cannot be carried out including the estimated pre-2013 emissions or allowances to reflect current ETS scope since, as already stated, these values are only available at aggregated level for all stationary installations.

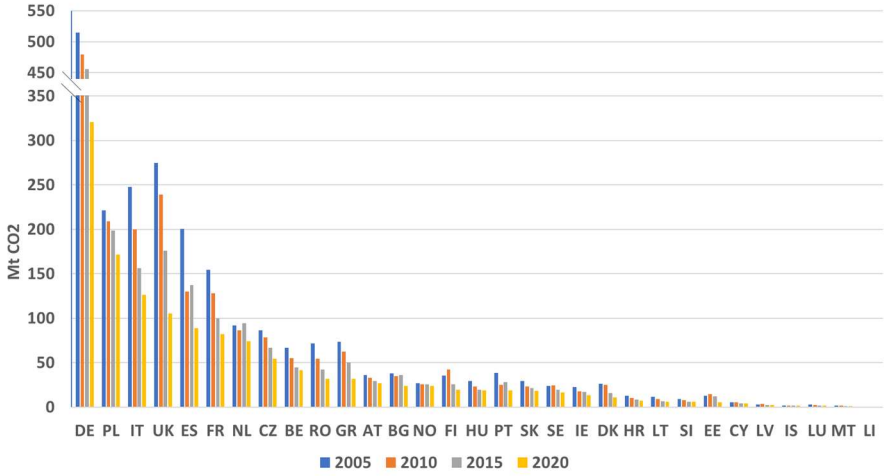


Figure 2.2 – *ETS emissions by country including the estimate to reflect current ETS scope. Countries in decreasing order of 2020 emissions.*

The countries' distribution of ETS emissions shows that Germany has a share of 24% in 2020, almost double the 13% of Poland. The share of the two countries increased from 31.1% in 2005 to 36.3% in 2020, the increasing trend is mainly due to Poland. On the other hand, Italy and the United Kingdom reduced their cumulative share from 22% in 2005 to 17.1% in 2020.

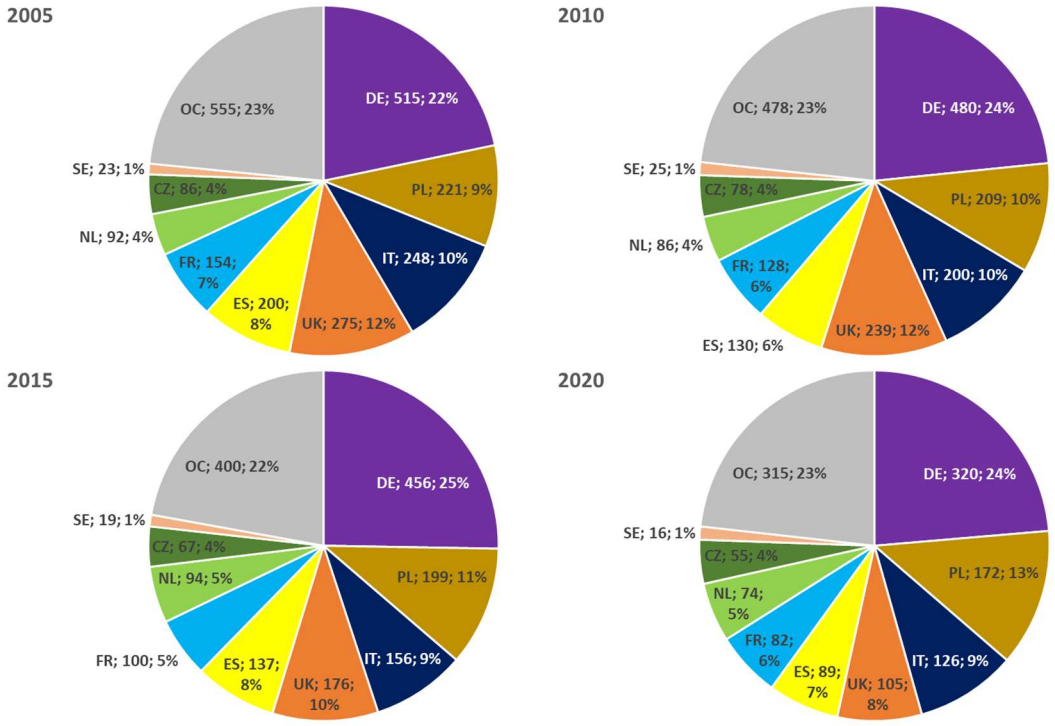


Figure 2.3 – *Share of ETS emissions by country in the years indicated. Countries in descending order of 2020 share. OC: Other Countries.*

Countries show a wide range of emission reduction percentages in 2020 compared to their year of entry into the ETS (Figure 2.4). Only Lichtenstein shows a slight increase of emissions.

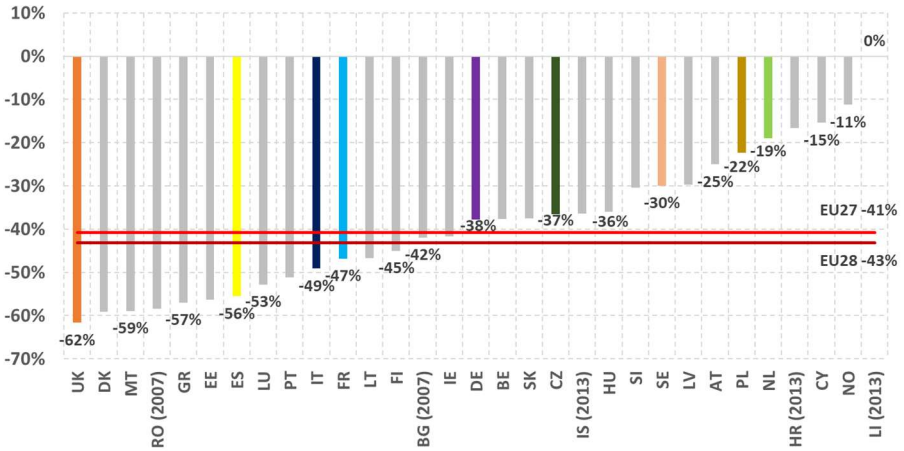


Figure 2.4 – *ETS emission reduction percentages in 2020 in European countries compared to their starting year (2005 unless otherwise indicated). Coloured bars represent the examined countries. Countries in ascending order.*

As several countries have different years of entry into the ETS a better comparison can be carried out with the average annual rates (Figure 2.5). The countries' ranking of average annual rates is quite the same observed with reduction percentages since the starting year. Among the biggest countries the UK, Spain and Italy recorded the highest average annual reduction rates, from -4.4% to -6.2%. France and Germany recorded -4.1% and -3.1%, respectively. Czech Republic, Sweden and Poland recorded respectively -3%, -2.3%, and -1.7%, while at the lower end the Netherlands recorded the lowest rate of -1.4%.

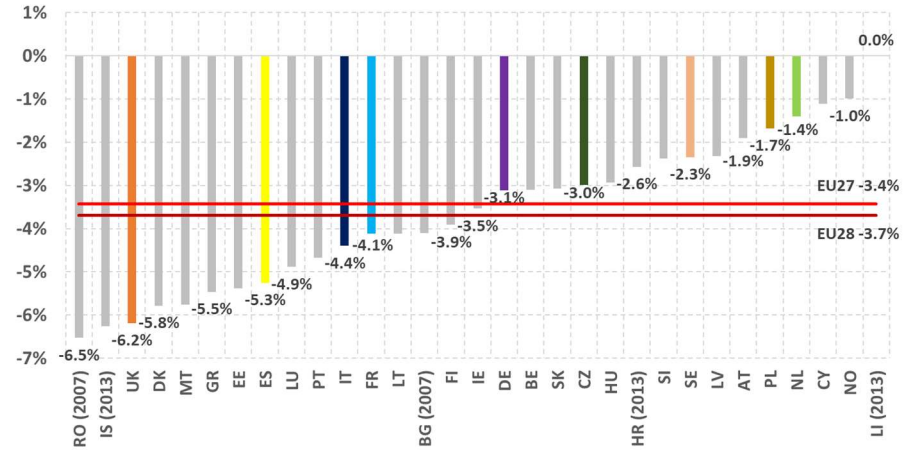


Figure 2.5 – *Average annual reduction rates of ETS emissions in European countries. The coloured bars represent the examined countries. Countries in ascending order.*

The following graph shows the contribution of emissions estimated from 2005 to 2012 to reflect current ETS scope following the ETS revision for phase 3. These estimates are only available at country level and cannot be considered in the analysis of sectoral emissions or allocated allowances. Such analyses therefore consider the verified emissions and allowances in accordance with the legislation in force in the emission year.

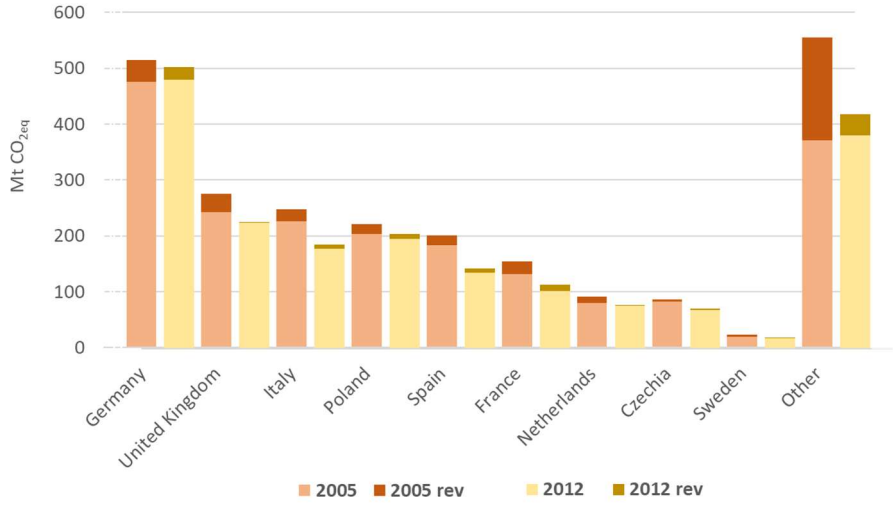


Figure 2.6 – *ETS verified emissions with estimates to reflect current ETS scope (2005 rev, 2012 rev) in the examined countries. Countries in decreasing order of 2005 emissions.*

Figure 2.7 shows the ETS emissions trend from 2005 to 2020 for all stationary installations with the estimates to reflect current ETS scope. The emissions decreased by 42.8% in 2020 compared to 2005.

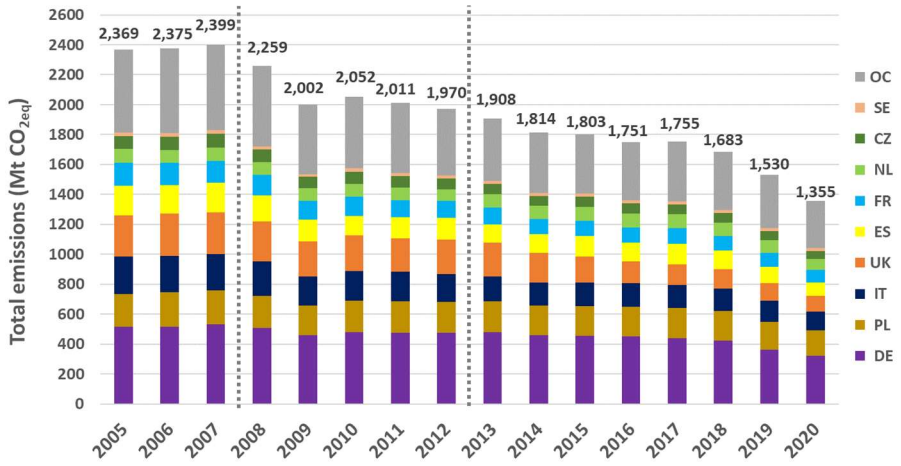


Figure 2.7 – *ETS verified emissions from all stationary installations with estimates to reflect current ETS scope in the examined countries and in the group of other countries (OC) from 2005 to 2020. The dotted lines divide the three ETS phases.*

Figure 2.8 shows the ETS emissions trends separately for combustion of fuels and industrial installations without the estimates to reflect current ETS scope, available only at aggregated level for all stationary installations. Without the estimates the emissions reduction since 2005 for all stationary installations is 32.7%. The graphs show how the emissions reduction is mainly due to combustion of fuels installations which reduced emissions by 43.1% since 2005. Industrial installations do not show a clear trend of emissions reduction, except from 2009 to 2012 when the effect of the economic crisis contracted the economy activities in many countries and consequently reduced emissions from such sectors. Subsequently, emissions from industrial sectors exceeded 2005 levels as a result of the extension of the ETS scope. From 2005 to 2020, industrial installations reduced the emissions by 6.5%, while from 2013 to 2020 the reduction is 9.3%. However, as for 2020 emissions it should be considered the role of economic activities lockdown in 2020 to contain the diffusion of SARS-CoV-2 pandemic. It is therefore clear that the overall reduction in ETS emissions is mainly due to the contribution of combustion of fuels installations showing a steady reduction since 2013 for all the biggest countries from 18.5% in Sweden to 53.2% in the United Kingdom. On the other hand, the emission trends for industrial installations are more heterogeneous, with countries as Sweden, Poland, and Czechia, among the biggest ones, which increased their emissions in 2020 by respectively 7%, 3.5%, and 0.5% compared to 2013, while the other examined countries reduced their emissions in the same period from 5.4% in the Netherlands to 26.5% in the United Kingdom.

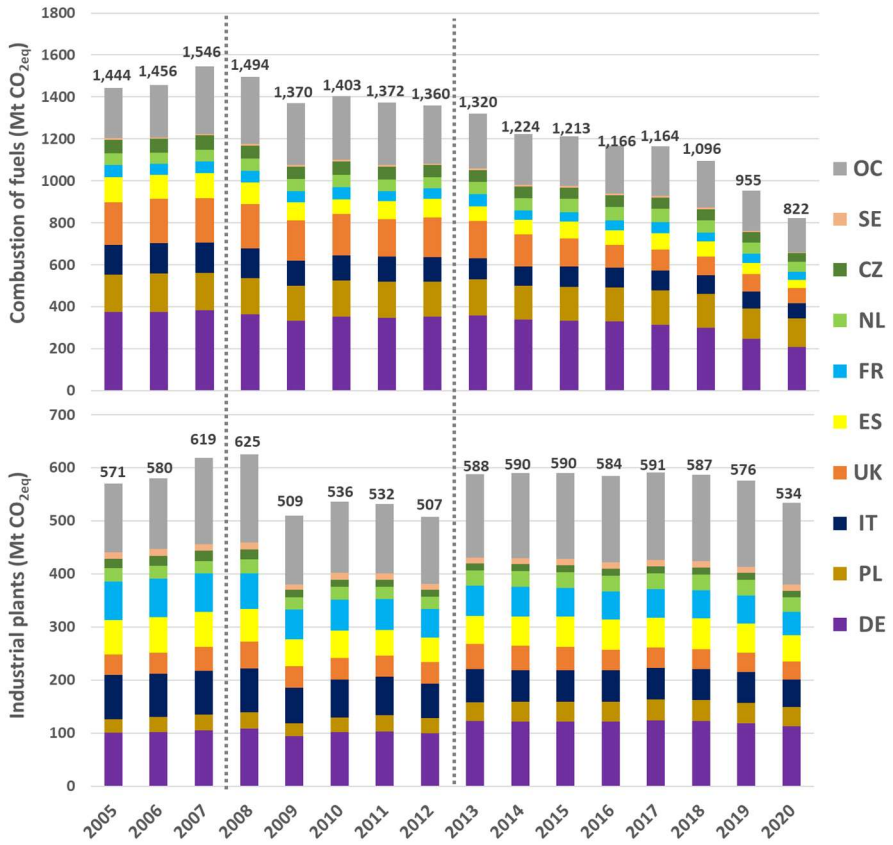


Figure 2.8 – *ETS verified emissions without estimates to reflect current ETS scope from combustion and industrial plants in the examined countries and in the group of other countries (OC) from 2005 to 2020. The dotted lines divide the three ETS phases.*

The following graphs show the emission trends from 2005 to 2020 expressed as percentage of 2005 level for the examined countries, the group of other countries, and the total ETS emissions. Figures 2.9 shows the trends for all the stationary installations considering also the estimates to reflect current ETS scope, while Figure 2.10 shows the trends for combustion of fuels and industrial installations without the estimates. The reductions in the main countries range from 19% in the Netherlands to 61.6% in the United Kingdom. The next three higher reductions, below the overall percentage (42.8%), are recorded for Spain (55.5%), Italy (49.1%), and France (46.8%).

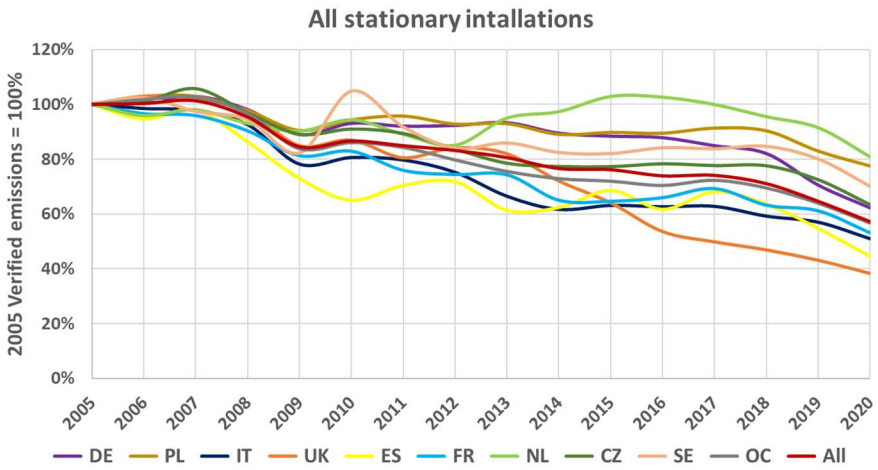


Figure 2.9 – *ETS emission trends for all stationary installations from 2005 to 2020 level for the examined countries, the group of other countries (OC), and the total ETS emissions (All). The emissions are expressed as percentage of 2005 and include the estimates to reflect current ETS scope.*

Without considering the estimates to reflect the current ETS scope the emission reductions by combustion of fuels installations from 2005 to 2020 in the biggest countries range from 15.3% in the Netherlands to 66.2% in Spain. As for the industrial installations the emission changes from 2005 to 2020 range from -38.5% in France to +44.3% in Poland. While combustion of fuels plants show the same trend shown by all installations with the estimates to reflect current ETS scope, no relevant reduction is evident for industrial emissions without considering such estimates. Moreover, it is also worth noting that the emission reduction for all countries in the period 2013-2020, when no effect is attributable to the estimates, is higher for combustion of fuels installations (37.8%) than industrial ones (9.3%). The emissions reduction for all installations in the 2013-2020 period is 29%.

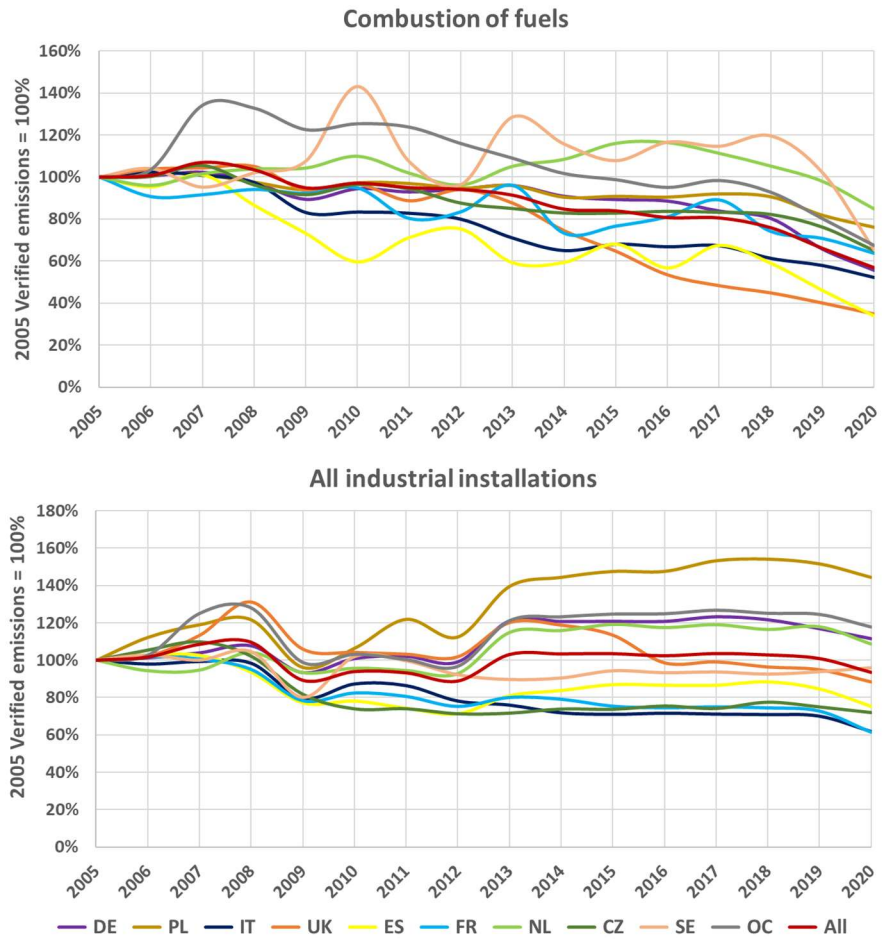


Figure 2.10 – *ETS emission trends for combustion of fuels and industrial installations from 2005 to 2020 for the examined countries, the group of other countries (OC), and the total ETS emissions (All). The emissions, without the estimates to reflect current ETS, are expressed as percentage of 2005.*

It is a quite rude approximation to add up the estimates to reflect current ETS scope to combustion of fuels or industrial installations, anyway it is clear that the addition of estimates to industrial installations explains the emission reductions since 2005 registered for all installations with current ETS scope. In such scenario the emission reduction in 2020 for the industrial installations is 42.3% compared to 2005, with biggest countries ranging from 15.8% in Poland to 53.4% in France (Figure 2.11). It is only an hypothetical scenario but it is very likely that the higher share of estimates to reflect current ETS scope should be added up to industrial installations than combustion of fuels installations considering the aim of ETS revision for the phase 3, mainly addressed to extend the ETS scope with new industrial activities.

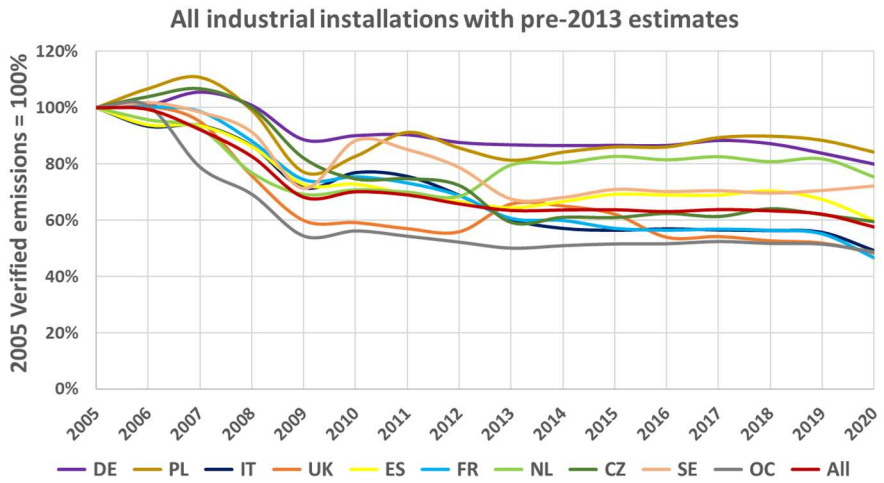


Figure 2.11 – *ETS emission trends for industrial installations from 2005 to 2020 for the examined countries, the group of other countries (OC), and total ETS emissions (All). The emissions are expressed as percentage of 2005 and include the estimates to reflect current ETS scope.*

Another factor to be considered in order to assess the decreasing trend of emissions since 2005 is the gap between the emission reductions for industrial plants with or without the estimates to reflect the current ETS scope. Figure 2.12 shows that the higher distances are for Poland and the group of other countries. This outcome gives some clue on the role of pre-2013 estimates which would deserve more attention in order to evaluate the ETS performance.

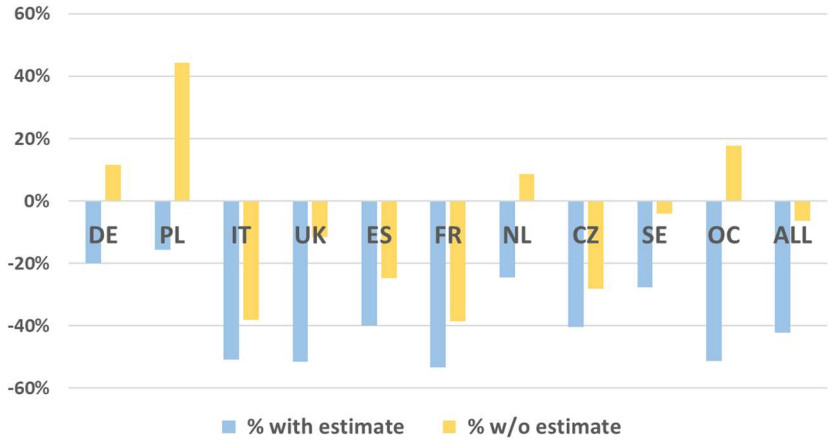


Figure 2.12 – *Percentage change in the period 2005-2020 of verified emissions from industrial plants with and without the estimates to reflect current ETS.*

The combustion of fuels installations account for the majority of emissions, with 60.6% in 2020 and, as already stated, emissions are mainly due to electricity and heat production. Industrial activities such as cement clinker, refining of mineral oil, and pig iron or steel followed with respectively 8.4%, 8.4% and 7.8% of ETS emissions. The other industrial activity sectors have much lower shares, from 2.6% of bulk chemicals downward. The top three mentioned industrial activities represent 21.4%, 21.2% and 19.7% of emissions from industrial installations in 2020 (Figure 2.13).

Table 2.2 shows verified emissions by activity sector with change since 2005. As the 2005 estimates by sector to reflect the current ETS scope are not available, the reported emissions reduction percentages in 2020 compared to 2005 are only indicative of the heterogeneous dynamics for the different activity sectors. The change since 2013 is more useful to evaluate the emission reductions by sector. The Mann-

Kendall test outcomes show that since 2013 only few sectors recorded significant decreasing emissions: combustion of fuels, refining of mineral oil, pig iron and steel, and coke.

Table 2.2 – *ETS emissions by main activity sector in all countries ($MtCO_2eq$) and % change in the periods 2005/2020 and 2013/2020. Countries in decreasing order of 2020 emissions. Mann-Kendall trend test significance: * $p<0.05$; ** $p<0.01$.*

Main activity sector	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Combustion of fuels	1,443.6	1,402.8	1,212.6	821.5	-43.1%**	-37.8%**
Cement clinker	148.5	126.2	116.6	114.2	-23.1%**	1.2%
Refining of mineral oil	138.2	129.8	127.9	113.3	-18.0%**	-11.7%**
Pig iron or steel	134.7	128.8	130.6	105.0	-22.0%**	-19.6%**
Bulk chemicals	12.2	29.3	38.2	35.7	191.6%**	-6.8%
Lime, or calcination…	32.2	31.0	30.7	27.3	-15.0%*	-12.7%
Ammonia	1.6	1.6	21.6	21.0	1213.0%**	-0.2%
Paper or cardboard	27.1	25.2	21.6	20.3	-25.1%**	-9.6%
Glass	19.7	18.7	17.9	17.2	-12.5%**	-2.8%
Ceramics	14.7	10.6	13.4	13.5	-8.2%	0.3%
Ferrous metals	10.0	4.9	12.9	10.6	5.9%	-17.6%
Coke	13.5	13.4	11.7	9.7	-28.0%**	-16.5%**
Hydrogen and synth. gas	1.4	0.7	8.4	8.8	548.8%	-1.6%
Primary aluminium	0.3	0.2	8.6	8.3	2355.3%**	-4.8%
Non-ferrous metals	0.5	0.6	6.6	6.7	1384.9%**	3.1%
Other activities	16.0	14.9	23.7	21.9	37.0%*	-5.5%
All stationary installations	**2,014.1**	**1,938.8**	**1,803.0**	**1,355.1**	**-32.7%****	**-29.0%***
All stationary installations*	**2,368.9**	**2,052.3**	**1,803.0**	**1,355.1**	**-42.8%****	

* including estimates to reflect current ETS scope.

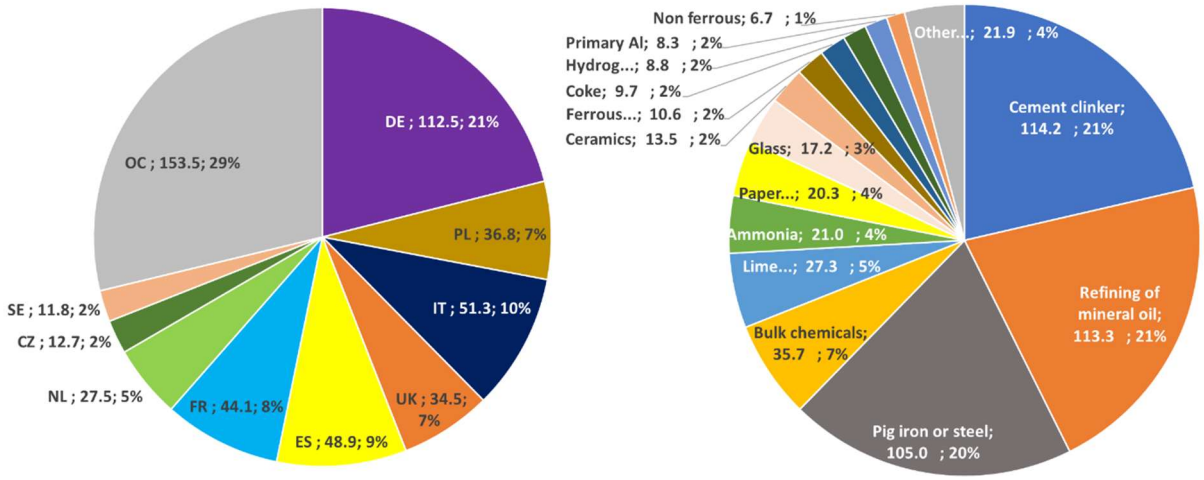


Figure 2.13 – *Distribution of ETS verified emissions ($MtCO_2eq$ and %) in 2020 from all industrial installations by country and by main activity sector.*

Table 2.3 reports the verified emissions for the examined countries, the group of other countries, and all countries. The Mann-Kendall test outcomes show that the only countries, among the biggest ones, with statistically significant decreasing emission trends for industrial installations since 2013 are Italy, United Kingdom, and France. The emissions trend for all installations, as well as trend for combustion of fuels, shows highly significant decrease both since 2005 and since 2013. The Mann-Kendall test for all installations is highly significant even without considering the estimates to reflect current ETS scope. Such analysis confirms that the decreasing trend observed for the overall emissions are mainly due to the combustion of fuels installations.

Table 2.3 – *ETS emissions in the examined countries ($MtCO_2eq$). The percentage changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of 2020 emissions in all stationary installations. Mann-Kendall trend test significance: * p<0.05; ** p<0.01.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
All stationary installations#	Germany	514.9	479.8	455.6	320.3	-37.8%**	-33.4%**
	Poland	221.3	208.8	198.7	171.7	-22.4%**	-16.5%
	Italy	247.5	199.5	156.2	126.0	-49.1%**	-23.4%*
	United Kingdom	274.8	238.9	176.0	105.4	-61.6%**	-53.2%**
	Spain	200.2	130.1	137.3	89.0	-55.5%**	-27.5%
	France	154.2	127.9	99.7	82.0	-46.8%**	-28.4%*
	Netherlands	91.5	86.4	94.1	74.1	-19.0%	-14.8%
	Czechia	86.1	78.5	66.6	54.7	-36.5%**	-19.3%
	Sweden	23.4	24.6	19.2	16.4	-29.9%**	-18.5%
	Other countries	554.9	477.8	399.5	315.5	-43.1%**	-24.8%**
	All countries	**2,368.9**	**2,052.3**	**1,803.0**	**1,355.1**	**-42.8%****	**-29.0%****
Combustion of fuels	Germany	374.2	353.1	333.8	207.8	-44.5%**	-42.1%**
	Poland	177.7	172.6	161.1	134.9	-24.0%**	-20.7%
	Italy	143.0	119.1	97.3	74.7	-47.8%**	-26.4%*
	United Kingdom	203.4	196.6	131.7	70.9	-65.2%**	-60.2%**
	Spain	118.8	70.8	80.8	40.2	-66.2%**	-42.8%
	France	59.5	56.4	45.6	37.9	-36.4%**	-33.8%
	Netherlands	55.1	60.5	64.0	46.6	-15.3%	-19.5%
	Czechia	64.8	62.5	53.6	42.0	-35.2%**	-23.8%*
	Sweden	7.1	10.1	7.6	4.6	-34.7%	-49.2%
	Other countries	240.0	300.9	237.1	162.0	-32.5%**	-38.1%**
	All countries	**1,443.6**	**1,402.8**	**1,212.6**	**821.5**	**-43.1%****	**-37.8%****
All industrial installations	Germany	100.8	101.7	121.8	112.5	11.6%*	-7.9%
	Poland	25.5	27.1	37.6	36.8	44.3%**	3.5%
	Italy	83.0	72.3	58.9	51.3	-38.1%**	-18.5%**
	United Kingdom	39.1	40.7	44.3	34.5	-11.7%*	-26.5%**
	Spain	64.9	50.7	56.4	48.9	-24.7%	-7.0%
	France	71.7	59.1	54.1	44.1	-38.5%**	-23.1%*
	Netherlands	25.3	24.2	30.2	27.5	8.7%*	-5.4%
	Czechia	17.7	13.1	13.0	12.7	-28.1%	0.5%
	Sweden	12.3	12.5	11.6	11.8	-4.0%	7.0%
	Other countries	130.3	134.5	162.5	153.5	17.8%	-2.7%
	All countries	**570.5**	**536.0**	**590.4**	**533.6**	**-6.5%**	**-9.3%**

including estimates to reflect current ETS scope.

In Table 2.4a-c are shown the main activity industrial sectors representing 96.8% of all ETS industrial emissions in 2020. The remaining sectors have been grouped in 'Other activities'.

Table 2.4a – *ETS emissions from industrial installations ($MtCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of total ETS emissions in 2020. Sectors in decreasing order of emissions from industrial installations in 2020. The activity sectors accounting for 96.8% of total ETS industrial emissions are shown. The remaining activities have been grouped in 'Other activities'.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Cement clinker	Germany	20.1	18.6	19.1	20.1	0.3%	5.9%
	Poland	8.3	9.5	9.4	11.2	33.8%	26.1%
	Italy	27.6	21.4	13.0	11.1	-60.0%	-22.5%
	United Kingdom	5.1	5.7	6.5	5.8	14.2%	-2.5%
	Spain	27.4	17.8	14.5	12.3	-55.2%	4.0%
	France	13.6	11.9	10.2	9.4	-31.1%	-17.9%
	Netherlands	0.6	0.5	0.4			
	Czechia	2.6	2.2	2.3	2.7	7.6%	38.5%
	Sweden	2.1	2.1	2.4	1.9	-8.2%	-10.6%
	Other countries	41.1	36.5	38.6	39.7	-3.4%	7.3%
	All countries	**148.5**	**126.2**	**116.6**	**114.2**	**-23.1%**	**1.2%**
Refining of mineral oil	Germany	26.4	22.3	23.7	21.5	-18.5%	-12.5%
	Poland	3.2	2.8	4.3	4.3	34.3%	8.0%
	Italy	24.7	23.3	18.9	15.4	-37.7%	-17.6%
	United Kingdom	12.9	11.4	8.4	7.0	-46.0%	-27.6%
	Spain	14.8	12.6	14.4	12.5	-15.2%	-12.0%
	France	17.3	15.1	11.1	7.8	-54.8%	-32.8%
	Netherlands	12.1	10.7	11.2	10.3	-14.7%	-2.2%
	Czechia	1.0	1.1	0.9	0.8	-19.3%	-1.9%
	Sweden	2.5	3.0	2.9	2.2	-11.4%	-16.3%
	Other countries	23.3	27.7	32.1	31.4	34.9%	-0.3%
	All countries	**138.2**	**129.8**	**127.9**	**113.3**	**-18.0%**	**-11.7%**
Pig iron or steel	Germany	27.5	27.5	29.5	25.1	-8.8%	-11.0%
	Poland	0.5	3.7	3.9	2.7	461.0%	-20.1%
	Italy	12.5	12.4	9.1	7.7	-38.4%	-29.3%
	United Kingdom	6.4	7.5	11.9	6.2	-2.7%	-54.6%
	Spain	7.8	7.1	7.4	5.1	-34.4%	-21.9%
	France	26.4	21.0	16.6	12.8	-51.7%	-28.0%
	Netherlands	6.5	6.3	6.3	5.8	-10.5%	-3.9%
	Czechia	9.8	6.1	5.7	5.4	-45.3%	-9.3%
	Sweden	4.1	4.3	3.7	5.1	25.0%	53.4%
	Other countries	33.2	32.9	36.3	29.1	-12.2%	-16.7%
	All countries	**134.7**	**128.8**	**130.6**	**105.0**	**-22.0%**	**-19.6%**
Bulk chemicals	Germany	0.9	5.6	8.0	7.9	813.6%	-2.2%
	Poland		0.8	4.3	4.1		-3.3%
	Italy	3.5	4.6	3.1	2.9	-18.1%	-22.6%
	United Kingdom	0.9	2.7	2.5	2.1	137.1%	-29.0%
	Spain	1.0	2.6	3.3	3.1	227.4%	10.0%
	France	0.9	0.7	1.4	1.3	46.9%	-7.4%
	Netherlands	1.3	3.0	3.8	3.4	163.8%	-13.3%
	Czechia	0.3	0.3	0.4	0.2	-18.9%	-34.9%
	Sweden			0.0	0.0		62.8%
	Other countries	3.6	9.1	11.6	10.8	198.8%	-1.4%
	All countries	**12.2**	**29.3**	**38.2**	**35.7**	**191.6%**	**-6.8%**
Lime, or calcination…	Germany	9.7	9.4	9.2	8.2	-15.7%	-11.8%
	Poland	2.0	1.9	2.1	1.8	-7.8%	-4.6%
	Italy	4.0	2.3	2.0	1.8	-53.7%	-21.7%
	United Kingdom	0.4	2.3	2.5	2.3	505.9%	-4.1%
	Spain	2.1	2.1	2.6	2.4	13.9%	-4.5%
	France	3.6	3.1	2.7	2.4	-33.3%	-22.6%
	Netherlands	0.1					
	Czechia	1.3	1.1	1.2	1.2	-9.7%	2.8%
	Sweden	0.9	0.8	0.7	0.6	-29.8%	-14.9%
	Other countries	8.1	8.1	7.9	6.6	-18.8%	-16.4%
	All countries	**32.2**	**31.0**	**30.7**	**27.3**	**-15.0%**	**-12.7%**

Table 2.4b – *ETS emissions from industrial installations ($MtCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of total ETS emissions in 2020. Sectors in decreasing order of emissions from industrial installations in 2020. The activity sectors accounting for 96.8% of total ETS industrial emissions are shown. The remaining activities have been grouped in 'Other activities'.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Ammonia	Germany	0.0	0.0	4.5	4.5	20637.5%	-5.2%
	Poland			1.8	1.8		11.0%
	United Kingdom	0.0	0.1	1.6	1.7	4515.7%	13.9%
	Spain			0.7	0.6		-10.2%
	France			1.5	1.5		3.4%
	Netherlands	1.3	0.4	3.8	3.3	159.7%	-6.9%
	Other countries	0.3	1.1	7.8	7.6	2698.9%	1.2%
	All countries	**1.6**	**1.6**	**21.6**	**21.0**	**1213.0%**	**-0.2%**
Paper or cardboard	Germany	6.5	6.2	5.3	4.8	-25.6%	-11.1%
	Poland	1.5	1.6	2.1	1.6	4.4%	-23.9%
	Italy	4.9	4.2	3.8	3.6	-26.8%	-7.2%
	United Kingdom	0.1	0.8	0.8	0.8	480.7%	-10.0%
	Spain	2.6	2.5	2.3	2.3	-11.4%	-3.6%
	France	1.0	0.5	0.3	0.2	-76.6%	-26.7%
	Netherlands	1.8	1.4	1.1	1.0	-46.0%	-17.2%
	Czechia	0.6	0.6	0.5	0.5	-23.1%	9.2%
	Sweden	1.3	0.7	0.4	0.4	-66.6%	-25.5%
	Other countries	6.7	6.8	5.0	5.0	-24.4%	-3.7%
	All countries	**27.1**	**25.2**	**21.6**	**20.3**	**-25.1%**	**-9.6%**
Glass	Germany	4.0	3.8	3.8	3.6	-8.9%	-3.1%
	Poland	1.4	1.3	1.5	1.7	24.0%	15.5%
	Italy	3.0	2.7	2.5	2.7	-9.6%	4.7%
	United Kingdom	0.3	1.2	1.2	1.1	258.7%	-9.6%
	Spain	2.6	2.1	1.9	1.8	-27.8%	-7.0%
	France	3.6	2.8	2.5	2.2	-37.6%	-10.4%
	Netherlands	0.6	0.6	0.5	0.4	-35.6%	-19.9%
	Czechia	0.8	0.7	0.7	0.7	-11.7%	12.7%
	Sweden	0.2	0.2	0.1	0.1	-74.7%	-14.9%
	Other countries	3.3	3.4	3.2	2.9	-13.2%	-6.3%
	All countries	**19.7**	**18.7**	**17.9**	**17.2**	**-12.5%**	**-2.8%**
Ceramics	Germany	1.8	2.7	2.0	1.9	3.9%	-11.9%
	Poland	1.2	0.5	1.0	1.0	-10.4%	0.7%
	Italy	0.4	0.1	2.5	2.5	513.9%	-2.1%
	United Kingdom	0.1	0.8	0.6	0.4	206.5%	-21.3%
	Spain	4.9	2.1	3.0	3.3	-32.9%	10.5%
	France	1.0	0.8	0.7	0.7	-31.3%	-12.8%
	Netherlands	0.1	0.5	0.6	0.6	970.5%	9.8%
	Czechia	0.7	0.4	0.4	0.4	-43.5%	4.5%
	Sweden	0.0	0.1	0.0	0.0	-46.6%	-62.0%
	Other countries	4.5	2.6	2.5	2.7	-40.7%	8.3%
	All countries	**14.7**	**10.6**	**13.4**	**13.5**	**-8.2%**	**0.3%**
Ferrous metals	Germany	0.1	0.5	3.7	2.9	3325.3%	-25.4%
	Poland		0.8	1.0	0.8		-7.1%
	Italy	1.4	0.4	1.6	1.2	-16.4%	-16.1%
	United Kingdom	6.4	1.2	0.4	0.4	-94.4%	-23.0%
	Spain	0.1	0.1	0.5	0.5	806.4%	-17.9%
	France	0.4	0.3	1.0	0.7	92.7%	-24.2%
	Czechia	0.1	0.1	0.1	0.1	27.0%	-33.8%
	Sweden	0.0	0.0	0.0	0.0	-34.3%	-16.4%
	Other countries	1.5	1.5	4.6	4.1	162.1%	-11.0%
	All countries	**10.0**	**4.9**	**12.9**	**10.6**	**5.9%**	**-17.6%**

Table 2.4c – *ETS emissions from industrial installations ($MtCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of total ETS emissions in 2020. Sectors in decreasing order of emissions from industrial installations in 2020. The activity sectors accounting for 96.8% of total ETS industrial emissions are shown. The remaining activities have been grouped in 'Other activities'.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Coke	Germany	2.9	3.6	3.8	3.3	12.5%	-11.5%
	Poland	2.5	2.6	2.0	1.4	-44.0%	-29.9%
	United Kingdom	6.0	6.0	5.7	4.7	-22.0%	-15.4%
	Spain	0.1	0.1	0.0	0.0	-68.5%	-31.9%
	Czechia	0.3	0.2	0.1	0.1	-53.0%	11.8%
	Other countries	1.7	1.1	0.2	0.1	-91.1%	-22.1%
	All countries	**13.5**	**13.4**	**11.7**	**9.7**	**-28.0%**	**-16.5%**
Hydrogen and syngas	Germany			3.0	3.0		-11.3%
	Italy	0.4		0.6	0.6	65.7%	-23.3%
	United Kingdom	0.1	0.1	0.6	0.6	326.5%	-3.5%
	Spain			0.8	0.8		-17.4%
	France	0.2	0.1	0.5	0.5	217.9%	-23.9%
	Netherlands	0.6	0.4	1.9	2.0	230.0%	14.3%
	Other countries	0.1	0.0	0.9	1.2	1805.3%	74.1%
	All countries	**1.4**	**0.7**	**8.4**	**8.8**	**548.8%**	**-1.6%**
Primary aluminium	Germany	0.0	0.0	1.4	1.4	14062.1%	0.7%
	United Kingdom			0.1	0.1		-27.3%
	Spain			1.4	1.1		-34.4%
	France	0.2	0.1	1.0	1.0	536.1%	4.1%
	Netherlands	0.1		0.1	0.2	20.4%	1.9%
	Czechia	0.0					
	Sweden			0.2	0.2		-4.4%
	Other countries	0.0	0.1	4.4	4.4	9788.2%	2.7%
	All countries	**0.3**	**0.2**	**8.6**	**8.3**	**2355.3%**	**-4.8%**
Non-ferrous metals	Germany	0.0		1.0	1.0	9745.7%	3.2%
	Poland	0.0		1.3	1.8	17925.9%	50.4%
	Italy			0.5	0.5		1.7%
	Spain	0.2	0.2	0.9	0.6	207.3%	-34.6%
	France			1.0	0.7		-31.8%
	Netherlands	0.0	0.0	0.0	0.0	7.9%	-43.2%
	Sweden			0.1	0.2		74.9%
	Other countries	0.2	0.4	1.7	1.8	799.7%	12.3%
	All countries	**0.5**	**0.6**	**6.6**	**6.7**	**1384.9%**	**3.1%**
Pulp	Germany	0.7	0.3	0.3	0.4	-51.3%	-0.5%
	Italy	0.4	0.5	0.6	0.6	30.2%	3.2%
	United Kingdom	0.1	0.5	0.5	0.5	360.4%	-13.1%
	Spain	0.7	0.7	0.7	0.6	-16.2%	-18.2%
	France	2.7	2.0	1.9	1.5	-42.6%	-23.4%
	Czechia	0.1	0.1	0.0	0.0	-82.9%	-69.6%
	Sweden	0.6	0.4	0.2	0.2	-68.8%	-28.1%
	Other countries	1.3	1.4	1.4	1.4	4.7%	5.4%
	All countries	**6.7**	**6.0**	**5.6**	**5.1**	**-23.4%**	**-11.9%**
Others activities	Germany	0.3	1.4	3.4	2.9	998.7%	-9.5%
	Poland	4.9	1.7	3.1	2.6	-47.7%	-10.9%
	Italy	0.1	0.4	0.8	0.8	464.3%	-3.0%
	United Kingdom	0.1	0.6	0.9	0.9	1143.0%	-2.7%
	Spain	0.8	0.8	1.9	1.9	133.2%	5.8%
	France	1.0	0.7	1.6	1.4	40.5%	-6.2%
	Netherlands	0.2	0.4	0.5	0.5	146.5%	17.0%
	Czechia	0.1	0.3	0.8	0.5	308.0%	-16.9%
	Sweden	0.6	0.9	0.8	0.8	48.0%	-5.1%
	Other countries	1.3	1.7	4.3	4.5	259.6%	3.7%
	All countries	**9.3**	**9.0**	**18.0**	**16.8**	**80.1%**	**-3.3%**

2.2.1 *Number of stationary installations and emissions*

In 2020, 9,762 installations are involved in the ETS (-2.7% of 2019 entities), just below the 2005 (9,873). In 2013, with the extension of ETS scope, the number of installations jumped to 10,774 (+5.9% compared to 2012).

Figure 2.14 shows the number of installations and emissions by installation for all countries since 2005. There has been a clear surge of installations at the beginning of the 3rd phase. At the end of such phase the number of installations decreased by 9.4% compared to 2013. It is noteworthy the significant and quite steady reduction of the average emissions by installation, by 32% in 2020 since 2005 and by 21.6% since 2013. Such intensity reduction is mainly due to the combustion of fuels installations as will be illustrated in the next pages.

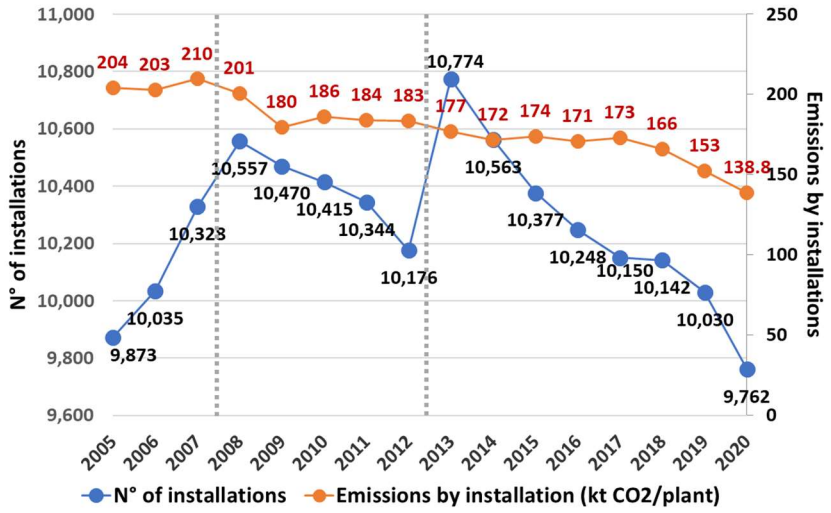


Figure 2.14 – *Trends of number of installations and emissions by installation since 2005. Dotted lines separate the three ETS phases.*

Figure 2.15 shows the number of installations and emissions by main activity sector in the examined countries in 2020. The countries are arranged in descending order of 2020 emissions. The installations recorded in the examined countries in 2020 account for 74% of overall ETS installations and for 76.7% of ETS emissions. Combustion of fuels installations account for the majority of installations at European level, 62.5% for all countries (45.9% from the biggest countries), and account for 60.6% of ETS emissions (48.7% from the biggest countries).

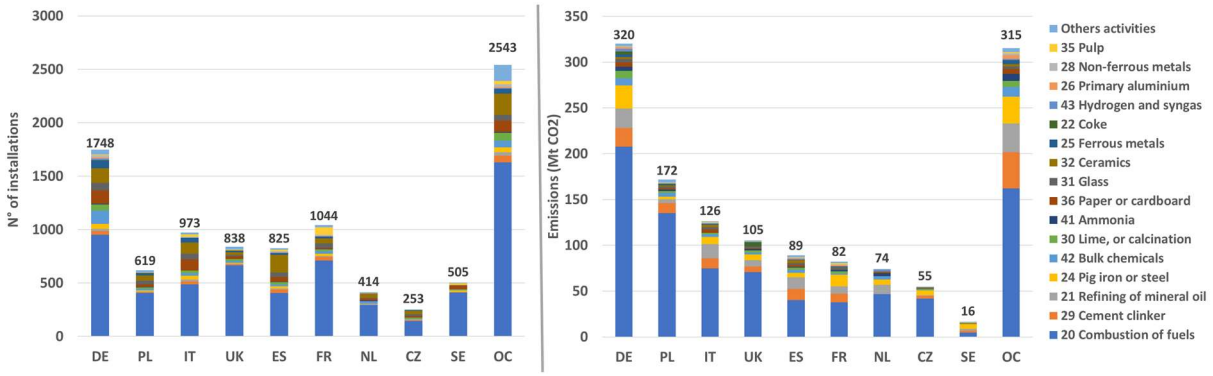


Figure 2.15 – *Number of installations and emissions by main activity sector in the examined countries and in the group of other countries (OC) in 2020. The declared activity sectors account for 98.8% of total ETS emissions. Countries in decreasing order of emissions.*

The examined countries account for 75% of industrial installations in all countries in 2020 and account for 71.2% of the industry's emissions. Unlike the trends observed in Figure 2.15 for combustion of fuels installation, for the industrial installations the decreasing order for number of plants is parallel with that of their emissions (Figure 2.16). Such results are coherent with a much higher variability of emissive intensity among countries in combustion of fuels installations than for industrial installations.

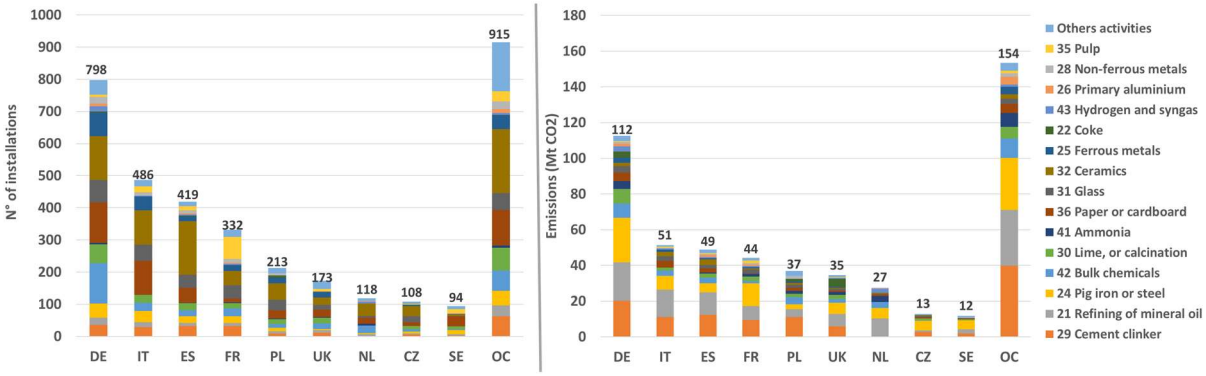


Figure 2.16 – *Number of installations and emissions by main industrial activity sector in the examined countries and in the group of other countries (OC) in 2020. The declared activity sectors account for 96.8% of total industrial ETS emissions. Countries in decreasing order of emissions by industrial sectors.*

The average emission intensity by installation depends fundamentally on the installation size and the fuel mix that fed the installations. Thermoelectric plants, among the combustion of fuels installations, have the highest emission intensity. The emissions for each activity sector also depend on economic factors, such as contingent demand for sector products. So, the emissions intensity provides only a generic, although useful, indication to compare the tendency to reduce or not the plant emission intensity by country (Table 2.5).

The average intensities recorded in 2020 for Germany, Poland, the Netherlands, and Czechia are above the average recorded for all countries (152.8 $ktCO_2eq$), from 32% in Germany to 99.9% in Poland. All countries' average intensity is shrinking, although Poland and Czechia show increasing trends since 2013.

Table 2.5 – *Average emissions intensity by installation ($ktCO_2eq$). The percentage changes in the periods 2005/2020 and 2013/2020 are also reported. Countries in decreasing order of total ETS emissions in 2020.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
All stationary installations	Germany	261.2	283.1	251.3	183.2	-29.8%	-29.6%
	Poland	240.1	258.0	273.7	277.4	15.5%	2.8%
	Italy	239.9	186.1	147.2	129.5	-46.0%	-10.6%
	United Kingdom	350.5	271.3	229.2	125.8	-64.1%	-58.5%
	Spain	232.1	127.5	165.4	107.9	-53.5%	-22.1%
	France	124.2	122.9	91.0	78.6	-36.7%	-20.9%
	Netherlands	390.1	226.0	213.9	179.0	-54.1%	-7.3%
	Czechia	214.2	211.7	205.7	216.1	0.9%	6.3%
	Sweden	32.9	36.6	32.7	32.5	-1.2%	-2.6%
	Other countries	145.4	150.9	146.3	124.1	-14.7%	-15.4%
	All countries	**204.0**	**186.2**	**173.8**	**138.8**	**-32.0%**	**-21.6%**

The industrial installations' average intensities for all countries (Table 2.6) have been lower than those recorded for all stationary installations up to 2018. The steady and fast decreasing intensity recorded for combustion of fuels installations (Figure 2.17) therefore makes it clear the higher intensity of industrial installations since 2019. The all countries' average intensity of industrial installations shows

a slight growing trend since 2013, interrupted in 2018 and following years. There is a considerable variability of the intensities among countries compared to the overall average. In 2020, Poland, the UK, and the Netherlands industrial intensities are higher than the all countries' average (146 $ktCO_2eq$) by 18.3%, 36.6%, and 59.6% respectively. Also for the group of other countries the average intensity is higher than the all countries' average (14.9%).

Table 2.6 – *Average emissions intensity by industrial installation ($ktCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are also reported. Countries in decreasing order of total ETS emissions in 2020.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
All industrial installations	Germany	145.9	177.2	152.9	141.0	-3.4%	-6.8%
	Poland	100.0	139.9	163.4	172.7	72.7%	15.2%
	Italy	189.9	181.8	117.3	105.6	-44.4%	-9.2%
	United Kingdom	444.0	210.9	250.5	199.4	-55.1%	-23.1%
	Spain	114.0	100.6	127.1	116.6	2.3%	3.9%
	France	208.5	199.7	154.5	132.9	-36.2%	-17.8%
	Netherlands	383.2	263.0	245.1	232.9	-39.2%	1.8%
	Czechia	119.5	103.6	111.3	117.7	-1.5%	9.8%
	Sweden	99.1	110.8	118.3	125.5	26.6%	20.6%
	Other countries	131.2	130.0	165.3	167.8	27.9%	10.6%
	All countries	**153.6**	**152.1**	**154.5**	**146.0**	**-5.0%**	**-1.2%**

Combustion of fuels installations (Table 2.7) usually have higher emission intensities than the majority of the industrial activity sectors, with the exception of refineries, pig iron or steel sector, cement and few other sectors. Among the examined countries, only France, the United Kingdom, Spain, and Sweden have average intensities below the overall average in 2020 (134.5 $ktCO_2eq$). The other biggest countries have intensities above the overall average, from 14% in Italy to 147% in Poland. Moreover Poland and Czechia are the only countries with intensities higher in 2020 than 2013.

Table 2.7 – *Average emissions intensity by combustion of fuels installation ($ktCO_2eq$). The percentage changes in the periods 2005/2020 and 2013/2020 are also reported. Countries in decreasing order of total ETS emissions in 2020.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Combustion of fuels	Germany	331.8	341.8	328.5	218.7	-34.1%	-36.5%
	Poland	300.6	297.6	324.8	332.4	10.6%	2.5%
	Italy	283.2	188.8	174.1	153.4	-45.8%	-10.4%
	United Kingdom	336.8	288.3	222.8	106.6	-68.4%	-66.4%
	Spain	534.9	157.6	209.4	98.9	-81.5%	-41.1%
	France	83.5	87.6	61.2	53.2	-36.3%	-25.7%
	Netherlands	393.3	213.9	201.8	157.5	-59.9%	-12.1%
	Czechia	273.3	270.7	259.1	289.4	5.9%	13.0%
	Sweden	15.2	20.0	15.6	11.3	-26.2%	-38.6%
	Other countries	154.5	162.5	135.7	99.5	-35.6%	-30.8%
	All countries	**234.4**	**203.6**	**185.0**	**134.5**	**-42.6%**	**-30.8%**

Figure 2.17 shows that trends of intensity in industrial sectors and combustion of fuel installations converge to comparable values in 2019.

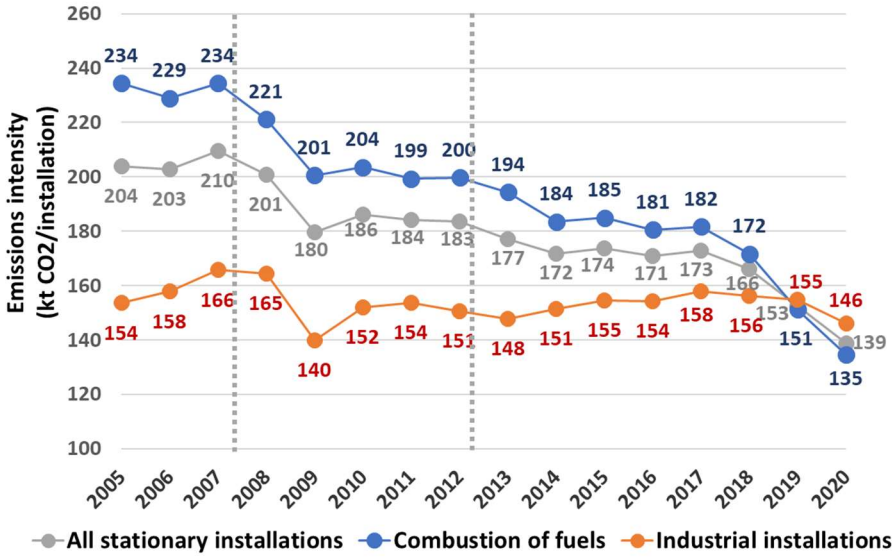


Figure 2.17 – *Trend of average emissions intensity for combustion of fuels, industrial installations and all stationary installations since 2005.*

Table 2.8a-c details the GHG emissions by installation in industrial sectors. The average intensity of industrial plants in 2020 was 146 $ktCO_2eq$. Sectors with highest intensity are refining of mineral oil (936 $ktCO_2eq$) and production of ammonia (808.3 $ktCO_2eq$), followed by production of coke and cement clinker (570.4 $ktCO_2eq$ and 521.5 $ktCO_2eq$) and the production of pig iron or steel sector (519.9 $ktCO_2eq$). The remaining sectors range from 11.8 $ktCO_2eq$ for production of glyoxal and glyoxylic acid to 315.2 $ktCO_2eq$ for production of soda ash and sodium bicarbonate (Figure 2.18).

Table 2.8a – *Average emissions intensity by industrial installation ($ktCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of ETS emissions in 2020. Sectors in decreasing order of ETS emissions from industrial installations in 2020. The activity sectors accounting for 96.8% of total ETS industrial emissions are shown. The remaining activities have been grouped in 'Other activities'.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Cement clinker	Germany	466.8	476.3	531.4	559.3	19.8%	5.9%
	Poland	245.1	727.2	858.3	1239.2	405.6%	54.1%
	Italy	521.5	403.4	351.4	381.5	-26.8%	28.2%
	United Kingdom	637.3	476.9	544.5	529.4	-16.9%	6.4%
	Spain	740.5	493.3	469.2	383.9	-48.1%	0.8%
	France	399.3	351.4	291.8	292.3	-26.8%	-10.2%
	Netherlands	621.1	527.9	402.6			
	Czechia	510.6	441.1	458.3	549.6	7.6%	38.5%
	Sweden	517.4	692.6	784.1	950.4	83.7%	34.2%
	Other countries	734.8	514.6	594.6	630.8	-14.2%	17.5%
	All countries	**540.0**	**472.6**	**493.9**	**521.5**	**-3.4%**	**16.0%**
Refining of mineral oil	Germany	613.3	856.6	1030.2	976.4	59.2%	-8.5%
	Poland	357.9	278.8	428.4	617.9	72.6%	54.3%
	Italy	1300.3	1293.0	1258.3	1025.7	-21.1%	-6.7%
	United Kingdom	1174.4	946.9	938.3	871.2	-25.8%	-0.5%
	Spain	1344.3	1142.7	1435.1	1254.0	-6.7%	-3.1%
	France	1155.7	1007.6	1009.3	783.7	-32.2%	-19.3%
	Netherlands	2019.8	1782.9	1604.2	1476.5	-26.9%	-2.2%
	Czechia	249.2	263.4	231.4	201.1	-19.3%	-1.9%
	Sweden	490.3	591.5	573.1	434.4	-11.4%	-16.3%
	Other countries	1164.0	813.8	917.6	951.7	-18.2%	2.8%
	All countries	**966.3**	**920.3**	**991.4**	**936.0**	**-3.1%**	**-2.2%**
Pig iron or steel	Germany	832.8	808.6	671.5	569.7	-31.6%	-9.0%
	Poland	60.6	414.9	429.1	272.1	348.8%	-28.1%
	Italy	329.2	303.1	239.6	220.2	-33.1%	-17.2%
	United Kingdom	912.9	1247.9	2388.3	1554.1	70.2%	-43.3%
	Spain	325.3	322.4	354.4	256.0	-21.3%	-14.1%
	France	1200.0	1047.7	723.6	607.4	-49.4%	-21.1%
	Netherlands	3243.7	3136.1	1583.7	1934.6	-40.4%	28.1%
	Czechia	891.4	607.9	475.2	893.4	0.2%	66.2%
	Sweden	293.2	310.4	265.1	394.8	34.7%	65.1%
	Other countries	626.6	522.5	698.7	633.6	1.1%	5.1%
	All countries	**635.3**	**582.8**	**588.4**	**519.9**	**-18.2%**	**-7.7%**
Bulk chemicals	Germany	47.8	295.3	87.5	62.4	30.5%	-28.6%
	Poland		771.0	355.2	341.2		-3.3%
	Italy	152.2	268.5	127.2	114.6	-24.7%	-22.6%
	United Kingdom	58.3	165.8	137.3	115.3	97.6%	-25.0%
	Spain	191.2	185.2	173.6	164.7	-13.8%	15.8%
	France	43.6	82.3	56.4	53.4	22.4%	-3.6%
	Netherlands	106.0	297.8	157.1	145.9	37.7%	-9.5%
	Czechia	98.0	105.3	62.8	34.0	-65.3%	-44.2%
	Sweden			0.7	1.0		62.8%
	Other countries	100.2	228.1	199.2	171.0	70.7%	-10.8%
	All countries	**92.7**	**227.5**	**136.6**	**111.8**	**20.7%**	**-17.6%**
Lime, or calcination	Germany	114.6	107.8	147.7	141.6	23.6%	-4.1%
	Poland	48.9	59.6	76.3	120.2	145.8%	71.8%
	Italy	84.3	66.0	74.2	73.4	-12.9%	0.2%
	United Kingdom	76.7	119.2	136.9	136.7	78.2%	7.1%
	Spain	89.7	95.1	116.4	106.8	19.1%	-0.2%
	France	180.3	179.5	169.3	150.3	-16.6%	-17.8%
	Netherlands	34.5					
	Czechia	92.7	114.7	117.0	117.1	26.4%	2.8%
	Sweden	81.5	65.4	76.7	69.9	-14.2%	-5.4%
	Other countries	118.1	103.5	107.7	93.2	-21.1%	-10.6%
	All countries	**101.4**	**99.4**	**116.2**	**112.5**	**10.9%**	**-0.5%**

Table 2.8b – *Average emissions intensity by industrial installation ($ktCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of ETS emissions in 2020. Sectors in decreasing order of ETS emissions from industrial installations in 2020. The activity sectors accounting for 96.8% of total ETS industrial emissions are shown. The remaining activities have been grouped in 'Other activities'.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Ammonia	Germany	21.6	21.4	892.7	897.7	4047.5%	-5.2%
	Poland			903.7	879.1		11.0%
	United Kingdom	18.4	37.4	819.6	851.2	4515.7%	13.9%
	Spain			663.3	641.1		-10.2%
	France			498.4	503.2		3.4%
	Netherlands	1269.9	399.2	627.1	549.6	-56.7%	-6.9%
	Other countries	90.7	175.9	1298.5	1088.2	1099.5%	30.1%
	All countries	**228.7**	**155.1**	**864.9**	**808.3**	**253.5%**	**7.5%**
Paper or cardboard	Germany	40.8	47.2	40.7	38.3	-6.1%	-9.0%
	Poland	46.5	63.0	84.3	61.6	32.5%	-23.9%
	Italy	34.0	32.2	35.9	33.8	-0.6%	-4.6%
	United Kingdom	22.7	30.7	32.4	34.4	51.5%	-10.0%
	Spain	31.1	41.5	47.4	48.7	56.5%	-1.6%
	France	28.7	31.1	27.8	21.4	-25.6%	-26.7%
	Netherlands	86.6	63.0	54.1	51.7	-40.3%	-12.9%
	Czechia	40.0	44.6	41.5	41.1	2.5%	0.1%
	Sweden	33.1	20.8	13.1	13.5	-59.2%	-20.9%
	Other countries	52.1	53.9	44.6	45.8	-12.0%	0.7%
	All countries	**40.8**	**43.2**	**41.4**	**39.6**	**-2.8%**	**-7.1%**
Glass	Germany	43.9	44.8	47.2	52.2	18.8%	18.0%
	Poland	38.5	37.9	45.4	52.1	35.2%	12.0%
	Italy	53.8	51.2	52.6	53.5	-0.6%	2.6%
	United Kingdom	63.0	87.5	86.7	80.7	28.1%	-9.6%
	Spain	43.2	41.4	46.1	44.9	3.9%	-0.2%
	France	75.0	64.0	58.2	53.6	-28.6%	-10.4%
	Netherlands	80.3	69.5	59.5	60.4	-24.8%	6.8%
	Czechia	42.6	35.1	38.1	37.6	-11.7%	12.7%
	Sweden	80.0	74.3	63.9	60.7	-24.2%	155.2%
	Other countries	52.9	52.5	56.9	54.6	3.1%	2.6%
	All countries	**51.2**	**50.1**	**52.1**	**52.6**	**2.7%**	**4.6%**
Ceramics	Germany	9.0	22.2	13.7	13.7	51.7%	-2.3%
	Poland	14.7	14.0	19.4	20.5	38.8%	14.6%
	Italy	15.7	8.9	22.2	23.4	49.2%	15.3%
	United Kingdom	7.6	14.1	24.3	17.4	129.9%	-21.3%
	Spain	16.4	8.3	15.9	19.8	20.8%	35.8%
	France	19.4	15.5	14.9	15.1	-22.1%	-1.1%
	Netherlands	28.6	15.0	15.9	16.1	-43.7%	21.3%
	Czechia	12.6	8.6	10.9	13.3	5.7%	18.0%
	Sweden	8.9	11.0	8.5	4.8	-46.6%	-52.6%
	Other countries	13.4	9.2	11.0	13.4	0.1%	42.0%
	All countries	**13.7**	**11.7**	**15.2**	**16.9**	**22.8%**	**19.9%**
Ferrous metals	Germany	28.2	92.7	48.7	39.7	40.8%	-19.3%
	Poland		66.8	53.4	49.1		-1.6%
	Italy	238.5	58.0	35.6	27.8	-88.3%	-14.2%
	United Kingdom	1608.2	310.4	27.3	22.6	-98.6%	-23.0%
	Spain	50.3	19.0	38.2	28.5	-43.4%	-23.0%
	France	45.5	53.7	53.0	39.0	-14.4%	-24.2%
	Czechia	7.3	14.6	22.6	23.0	217.6%	15.9%
	Sweden	24.2	22.2	18.9	15.9	-34.3%	-16.4%
	Other countries	55.2	48.4	94.8	94.2	70.7%	1.4%
	All countries	**161.8**	**64.3**	**53.3**	**45.8**	**-71.7%**	**-11.9%**

Table 2.8c – *Average emissions intensity by industrial installation ($ktCO_2eq$). The % changes in the periods 2005/2020 and 2013/2020 are reported. Countries in decreasing order of ETS emissions in 2020. Sectors in decreasing order of ETS emissions from industrial installations in 2020. The activity sectors accounting for 96.8% of total ETS industrial emissions are shown. The remaining activities have been grouped in 'Other activities'.*

Activity	Countries	2005	2010	2015	2020	Δ% 2005/2020	Δ% 2013/2020
Coke	Germany	734.8	892.1	937.9	826.4	12.5%	-11.5%
	Poland	224.7	200.5	218.4	173.0	-23.0%	-21.1%
	United Kingdom	3023.5	2979.9	5667.7	4714.9	55.9%	69.1%
	Spain	26.9	17.5	14.0	12.7	-52.7%	2.1%
	Czechia	84.5	85.1	102.1	119.1	40.9%	11.8%
	Other countries	556.3	533.7	198.6	148.2	-73.4%	-22.1%
	All countries	**517.7**	**516.3**	**650.8**	**570.4**	**10.2%**	**-1.8%**
Hydrogen and syngas	Germany			190.4	189.3		-22.4%
	Italy	374.7		209.6	207.0	-44.8%	-23.3%
	United Kingdom	134.2	111.2	299.1	286.1	113.2%	-3.5%
	Spain			280.7	257.4		-17.4%
	France	161.1	144.0	127.6	128.1	-20.5%	-23.9%
	Netherlands	123.3	206.0	311.9	339.2	175.0%	14.3%
	Other countries	64.2	42.2	142.7	203.8	217.5%	74.1%
	All countries	**150.1**	**141.9**	**208.8**	**219.1**	**46.0%**	**-6.6%**
Primary aluminium	Germany	9.7	10.1	175.8	172.1	1670.3%	0.7%
	United Kingdom			83.6	57.7		45.4%
	Spain			349.0	265.1		-34.4%
	France	154.1	82.8	337.9	326.7	112.0%	4.1%
	Netherlands	41.8		62.4	151.1	261.2%	1.9%
	Czechia	4.3					
	Sweden			223.5	245.2		-4.4%
	Other countries	22.4	36.6	337.0	341.5	1421.3%	2.7%
	All countries	**42.3**	**39.9**	**276.3**	**268.1**	**533.6%**	**1.3%**
Non-ferrous metals	Germany	5.3		48.6	49.5	837.7%	3.2%
	Poland	9.8		217.6	295.3	2904.3%	50.4%
	Italy			56.4	52.3		1.7%
	Spain	102.6	68.4	101.8	70.1	-31.7%	-34.6%
	France			87.0	61.4		-31.8%
	Netherlands	24.2	7.0	42.4	26.2	7.9%	-43.2%
	Sweden			129.1	154.7		74.9%
	Other countries	40.1	29.9	76.1	78.4	95.6%	7.4%
	All countries	**40.9**	**35.3**	**82.0**	**80.6**	**96.8%**	**1.9%**
Pulp	Germany	90.0	45.9	47.7	50.1	-44.3%	-0.5%
	Italy	21.0	24.5	27.0	30.2	43.9%	14.1%
	United Kingdom	99.4	52.9	90.3	76.3	-23.3%	-13.1%
	Spain	41.5	53.0	56.1	45.4	9.5%	-12.0%
	France	35.9	26.6	25.3	22.4	-37.7%	-15.6%
	Czechia	45.1	33.9	9.4	7.7	-82.9%	-69.6%
	Sweden	42.4	33.7	15.3	14.3	-66.4%	-28.1%
	Other countries	49.4	39.3	42.6	43.6	-11.6%	12.0%
	All countries	**40.4**	**33.7**	**33.4**	**31.8**	**-21.5%**	**-5.4%**
Others activities	Germany	267.0	96.4	73.8	63.8	-76.1%	-11.4%
	Poland	1233.6	243.5	171.4	151.8	-87.7%	-10.9%
	Italy	34.6	54.2	45.0	41.1	18.8%	-18.3%
	United Kingdom	23.8	35.8	37.9	34.1	43.4%	-10.1%
	Spain	159.1	76.1	135.4	132.5	-16.7%	20.9%
	France	69.1	74.6	67.6	61.8	-10.6%	-2.0%
	Netherlands	106.6	139.3	73.8	65.7	-38.4%	2.4%
	Czechia	66.6	87.2	108.0	77.7	16.6%	-16.9%
	Sweden	20.2	41.4	104.5	92.8	360.5%	37.1%
	Other countries	7.7	9.5	25.3	29.8	285.6%	21.4%
	All countries	**41.4**	**32.5**	**54.0**	**52.6**	**27.2%**	**4.5%**

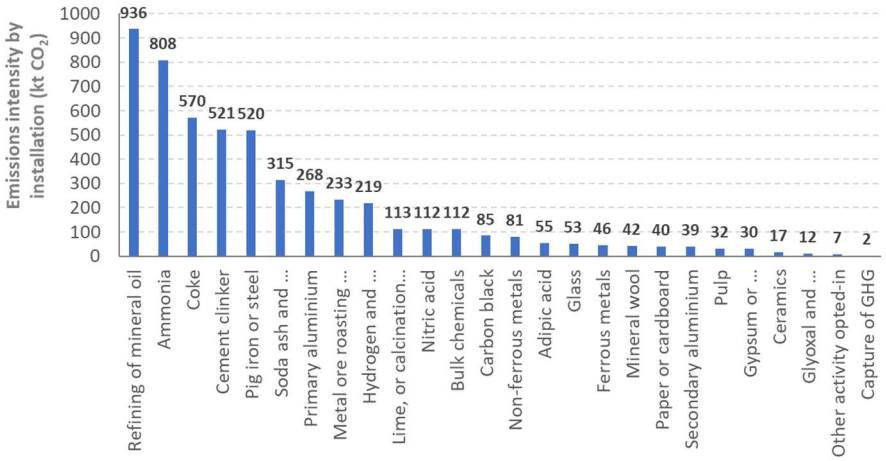


Figure 2.18 – *Average emissions intensity by industrial installation (ktCO₂eq). Sectors in decreasing order of intensity in 2020 for all ETS industrial installations.*

2.2.2 *Verified emissions and allocated allowances*

As already stated, the common method to allocate allowances in phase 1 of the EU-ETS (2005-2007) and phase 2 (2008-2012) was free allocation on the basis of historical emissions by installation. Phase 2 introduced the auction mechanism for a minimum number of allowances. Such mechanism has become the common method of allocation in phase 3 (2013-2020). The freely allocation in the last phase follows harmonised benchmark criteria at European level also considering the sector specific risk of carbon leakage due to the costs of climate policies, i.e. the transfer of emissions that may occur if companies transfer production to countries with less stringent emission limits (EC, 2021[b]). The risk of carbon leakage may be higher for some energy-intensive industries. In order to safeguard the competitiveness of such industries, the sectors at high risk of carbon leakage receive higher free allowances than other sectors. No free allocation is granted for electricity production.

Figure 2.19 shows the ratio between allocated allowances and verified emissions. As for total allowances/emissions, data account for the estimates to reflect the current scope of ETS, such estimates are available for all stationary installation but not available separately for free and auctioned or sold allowances. The auctioning of allowances in 2013 and 2014 available only at overall level, as part of the NER300 program, has been considered. The ratios between free allocated allowances and verified emissions for 1st and 2nd phases higher than 1 represent the over-allocation, mainly from 2009 as a consequence of the economic crisis which reduced the production activities. Since 2013, with the start of phase 3, the ratios for free allowances dropped below 1. The ratio of total allocated allowances (freely allocated plus auctioned or sold) to verified emissions, over 1 in 2013, fluctuated below 1 in the next years, except in 2020 when total allocated allowances was 3% higher than verified emissions. The widest fluctuations is due to auctioned or sold allowances because they are directly dependent on contingent market factors that immediately reflect on transactions. On the other hand, the trend of freely allocated allowances in the 3rd phase shows a gradual decrease from 53.1% to 44.5% compared to the verified emissions in the period 2013-2018, followed by an upward trend in the next years: 47.1% in 2019 and 49.3% in 2020.

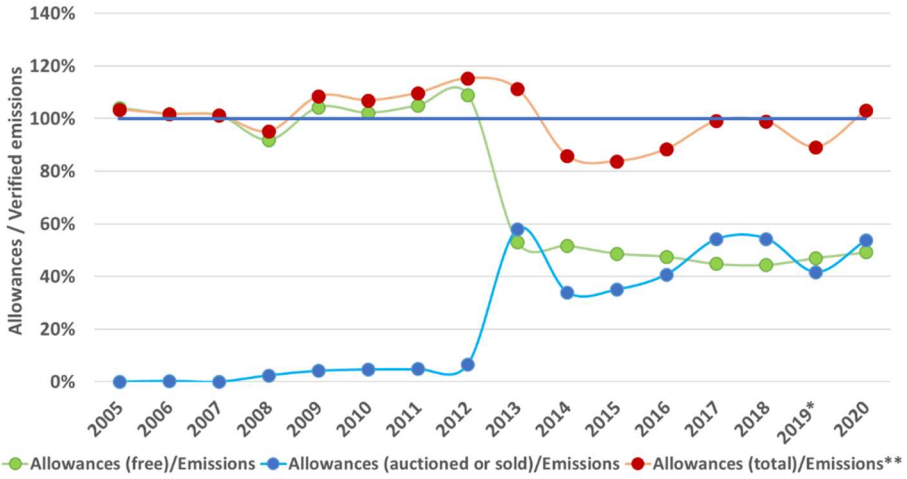


Figure 2.19 – *Percentage of allowances compared to verified emissions. Auctioned allowances and total allowances include NER300 program. * The UK figure for allowances auctioned or sold in 2019 are not available, ratios for total allowances and auctioned or sold allowances do not consider UK data in 2019. ** Data account for the estimates to reflect the current scope of ETS for allowances and emissions.*

Figure 2.20 shows the ratio of freely allocated allowances to verified emissions for all stationary installations, combustion of fuels and industrial installations. The prevalence of power plants in combustion of fuels activity sector is evident from the much lower ratio than for industrial installations which show ratios just below 1 only from 2017 (0.99) to 2019 (0.98). For all other years the ratios are much higher than 1 and in the phase 3, from 10.8% in 2013 to 2.6% in 2017 and 2.2% in 2020.

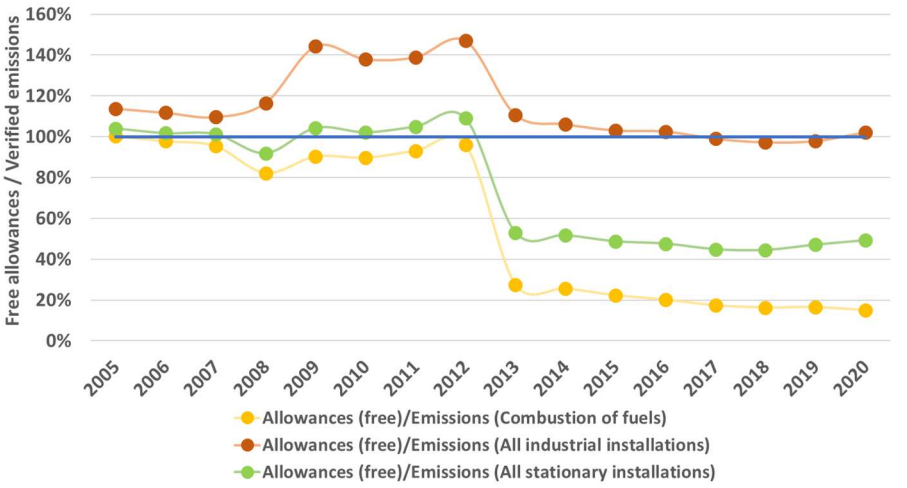


Figure 2.20 – *Ratio of freely allocated allowances to verified emissions for all stationary installations, combustion of fuels and industrial installations.*

As for the share of free allowances in total allowances Figure 2.21 show the fall of the percentage in 2013 and the slight reduction in the following years up to 2018, with a significant increase in 2019 followed by further decrease in 2020.

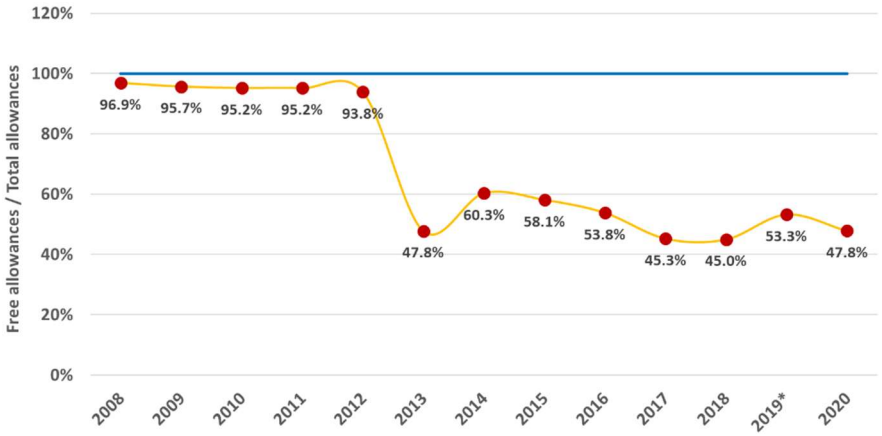


Figure 2.21 – *Percentage of free allocated allowances compared to total allowances from 2008 to 2020 for the ETS system. Total allowances include NER300 program. * UK allowances auctioned or sold in 2019 are not available so for this year UK data are not considered.*

Table 2.9 shows the percentage of freely allocated allowances compared to total allowances from 2008 to 2020 for all countries. Compared to 47.8% for the whole system in 2020, some countries recorded free allowances share close to 70% as France, the Netherlands, Austria, and Belgium. Sweden recorded the highest share of 79%.

Table 2.9 – *Percentage of free allowances compared to total allowances by country from 2008 to 2020.*

Phase	Phase 2					Phase 3							
Country	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
DE	86.8%	88.5%	88.7%	88.8%	88.0%	45.1%	56.5%	52.5%	49.0%	43.3%	45.9%	52.5%	55.9%
PL	100.0%	100.0%	100.0%	100.0%	99.9%	72.6%	90.0%	85.3%	76.9%	45.5%	46.0%	37.3%	25.0%
UK	98.2%	89.6%	86.0%	87.9%	89.3%	38.3%	49.6%	44.9%	40.6%	33.3%	33.7%	*	30.2%
IT	100.0%	100.0%	100.0%	100.0%	100.0%	46.7%	56.1%	51.1%	47.8%	42.1%	41.9%	55.6%	52.5%
ES	99.8%	99.5%	100.6%	100.0%	100.0%	43.1%	52.8%	49.3%	46.3%	40.9%	40.6%	53.8%	53.2%
FR	100.0%	100.0%	100.0%	100.0%	100.0%	59.4%	69.8%	66.3%	63.1%	56.9%	56.0%	69.6%	68.6%
NL	100.0%	100.0%	91.4%	95.7%	95.6%	58.9%	69.4%	66.0%	62.4%	57.4%	57.3%	70.6%	69.5%
CZ	100.0%	100.0%	100.0%	100.0%	97.1%	73.8%	83.3%	74.4%	62.5%	47.9%	42.1%	47.1%	37.8%
SE	100.0%	100.0%	100.0%	100.0%	100.0%	76.0%	82.9%	80.0%	77.4%	72.6%	71.6%	80.4%	79.0%
Average	**96.0%**	**95.1%**	**94.2%**	**94.7%**	**94.4%**	**52.4%**	**63.8%**	**58.8%**	**54.2%**	**45.1%**	**45.4%**	**53.8%***	**47.6%**
AT	100.0%	98.7%	98.7%	99.4%	96.8%	61.0%	71.3%	67.8%	64.7%	59.3%	58.9%	71.9%	70.9%
BE	100.0%	100.0%	100.0%	100.0%	86.0%	58.7%	69.2%	65.3%	62.6%	57.2%	56.8%	69.1%	68.2%
BG	100.0%	100.0%	100.0%	100.0%	99.7%	58.8%	76.3%	52.7%	50.2%	36.9%	33.1%	36.2%	30.3%
CY	100.0%	100.0%	100.0%	100.0%	100.0%	92.4%	97.9%	100.0%	100.0%	68.9%	57.8%	65.5%	44.9%
DK	100.0%	100.0%	100.0%	100.0%	89.4%	48.7%	58.2%	51.7%	47.0%	40.2%	38.9%	51.9%	49.0%
EE	100.0%	100.0%	100.0%	100.0%	100.0%	68.3%	86.6%	71.7%	56.8%	41.9%	26.6%	35.2%	33.7%
FI	100.0%	100.0%	100.0%	100.0%	100.0%	57.1%	67.1%	62.6%	58.5%	52.4%	51.1%	64.5%	63.0%
GR	100.0%	100.0%	100.0%	86.8%	88.2%	29.6%	40.0%	36.9%	33.9%	29.4%	29.3%	40.1%	39.3%
HR						100.0%	100.0%	29.9%	55.2%	49.5%	49.0%	59.8%	59.2%
HU	100.0%	100.0%	100.0%	100.0%	76.3%	68.2%	51.2%	49.0%	45.8%	40.5%	40.4%	50.9%	49.9%
IE	100.0%	99.1%	99.1%	99.1%	100.0%	35.3%	44.3%	44.2%	41.2%	35.8%	35.5%	49.6%	48.5%
IS						100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	61.5%	48.5%
LI	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	4.0%	2.0%
LT	100.0%	100.0%	100.0%	90.4%	77.1%	57.8%	69.2%	63.3%	61.0%	51.5%	51.5%	59.3%	56.4%
LU	100.0%	100.0%	100.0%	100.0%	99.8%	52.6%	63.1%	60.2%	56.9%	51.3%	51.0%	63.5%	62.6%
LV	100.0%	100.0%	100.0%	100.0%	100.0%	49.1%	58.6%	51.8%	46.7%	39.9%	38.0%	46.4%	43.2%
MT	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NO	100.0%	38.7%	55.8%	57.1%	46.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	46.2%	34.3%
PT	100.0%	100.0%	100.0%	100.0%	100.0%	40.9%	52.1%	47.6%	44.3%	38.8%	38.7%	51.1%	50.2%
RO	100.0%	100.0%	100.0%	100.0%	99.2%	54.2%	64.8%	53.9%	44.5%	37.6%	31.1%	40.9%	36.1%
SI	100.0%	100.0%	100.0%	100.0%	100.0%	33.4%	45.8%	40.2%	34.8%	29.3%	28.8%	38.8%	37.7%
SK	100.0%	100.0%	100.0%	100.0%	100.0%	51.0%	61.9%	57.6%	54.0%	47.8%	48.0%	57.5%	56.7%
Other	**100.0%**	**97.3%**	**98.6%**	**96.6%**	**92.1%**	**54.8%**	**64.6%**	**56.4%**	**52.9%**	**45.9%**	**43.9%**	**52.0%**	**48.3%**
Total**	**96.9%**	**95.7%**	**95.2%**	**95.2%**	**93.8%**	**47.8%**	**60.3%**	**58.1%**	**53.8%**	**45.3%**	**45.0%**	**53.3%***	**47.8%**

** UK allowances auctioned or sold in 2019 are not available so for this year UK data are not considered.*
*** Including NER300 program auctioned allowances.*

Table 2.10 shows the percentage of freely allocated allowances compared to verified emissions from 2008 to 2020 for all countries. As already stated the ratio of freely allocated allowances to verified emissions allows to evaluate allocation surplus (above 1) or deficit (below 1) of free allowances. Countries show heterogeneous patterns. During the 2nd phase (2008-2012), the great majority of countries shows relevant surpluses of free allocation with few exceptions, as Germany and the United Kingdom among the biggest countries. During the 3rd phase (2013-2020) only Sweden and Lichtenstein show significant surpluses.

Table 2.10 – *Percentage of free allowances compared to verified emissions by country from 2008 to 2020.*

Phase	Phase 2					Phase 3							
Country	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
DE	80.2%	89.2%	85.9%	86.9%	91.7%	35.2%	35.8%	34.9%	34.2%	34.3%	34.5%	38.8%	42.6%
PL	98.5%	105.7%	103.0%	102.1%	108.2%	66.0%	61.2%	50.1%	42.9%	35.5%	33.2%	33.6%	25.2%
UK	80.7%	92.7%	92.8%	101.0%	98.9%	29.6%	33.0%	34.7%	37.3%	38.6%	39.8%	41.8%	45.6%
IT	96.2%	113.0%	104.4%	102.8%	107.6%	52.8%	51.3%	46.4%	45.7%	44.4%	46.1%	45.8%	46.0%
ES	94.1%	110.1%	124.3%	114.1%	113.6%	54.8%	49.0%	44.0%	48.5%	43.1%	45.0%	52.8%	64.2%
FR	104.4%	115.7%	115.3%	127.0%	129.8%	72.0%	80.2%	77.7%	74.1%	66.4%	69.3%	70.3%	78.2%
NL	91.9%	103.5%	100.1%	111.1%	113.8%	56.9%	54.1%	49.7%	47.6%	48.6%	49.9%	50.7%	55.2%
CZ	106.4%	116.4%	113.9%	116.5%	124.7%	77.2%	70.5%	63.2%	55.0%	47.5%	41.1%	36.4%	32.9%
SE	103.5%	120.6%	103.9%	113.8%	124.2%	144.4%	141.8%	133.0%	123.8%	117.9%	109.7%	110.3%	116.8%
Average	**90.1%**	**101.5%**	**99.5%**	**101.6%**	**104.9%**	**49.7%**	**49.2%**	**45.9%**	**44.6%**	**42.3%**	**42.3%**	**44.8%**	**46.7%**
AT	95.8%	110.8%	98.8%	100.5%	105.6%	75.4%	78.1%	71.5%	70.7%	65.2%	68.2%	63.5%	67.2%
BE	99.9%	122.9%	111.8%	122.4%	136.1%	82.0%	82.3%	76.8%	78.2%	76.2%	73.0%	71.8%	75.1%
BG	100.0%	126.8%	105.2%	103.8%	122.1%	66.7%	57.3%	48.7%	48.7%	37.8%	37.9%	34.7%	33.6%
CY	86.3%	94.9%	106.2%	126.9%	142.3%	92.7%	75.2%	69.8%	58.1%	50.6%	47.8%	42.1%	29.9%
DK	90.0%	93.6%	94.3%	111.0%	132.0%	56.6%	60.2%	61.0%	51.8%	55.0%	51.7%	59.3%	59.5%
EE	86.2%	114.2%	81.7%	107.7%	105.2%	55.2%	53.6%	58.9%	43.7%	33.5%	23.7%	37.1%	53.1%
FI	101.0%	107.9%	91.8%	108.3%	129.4%	72.9%	75.3%	79.0%	69.7%	71.9%	64.7%	69.1%	77.9%
GR	91.2%	99.3%	107.9%	112.2%	106.1%	25.6%	26.5%	29.3%	30.9%	28.7%	29.6%	33.9%	42.1%
HR						60.0%	60.7%	57.7%	57.0%	54.7%	59.6%	57.9%	58.3%
HU	92.2%	105.4%	111.8%	111.0%	116.1%	94.2%	53.0%	52.7%	52.5%	48.6%	49.1%	48.9%	48.9%
IE	98.0%	115.9%	121.1%	136.8%	128.7%	33.5%	29.7%	31.6%	29.7%	30.3%	32.1%	34.2%	35.6%
IS						86.3%	86.0%	81.8%	81.7%	78.0%	75.5%	81.8%	79.0%
LI	106.1%	145.7%	981.2%	1018.6%	1436.8%	220.3%	601.6%	567.9%	954.3%	240.5%	307.3%	434.8%	113.5%
LT	123.0%	130.8%	127.5%	143.4%	146.4%	92.2%	95.7%	93.0%	100.0%	92.1%	92.3%	81.6%	75.0%
LU	118.5%	114.1%	110.5%	121.2%	124.9%	74.3%	67.6%	78.7%	85.0%	83.5%	82.8%	79.1%	83.7%
LV	135.9%	195.2%	147.0%	158.1%	182.2%	100.9%	102.8%	89.9%	86.0%	85.5%	61.2%	59.2%	64.4%
MT	104.4%	111.8%	115.0%	112.2%	105.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NO	39.0%	41.5%	41.5%	44.1%	45.4%	71.7%	69.6%	66.5%	67.9%	64.0%	64.2%	64.7%	65.4%
PT	101.7%	108.9%	133.9%	131.9%	130.4%	50.8%	50.1%	41.1%	43.5%	36.4%	40.8%	49.9%	56.0%
RO	112.5%	150.7%	158.4%	146.0%	157.1%	94.4%	71.3%	70.0%	74.1%	67.0%	53.0%	57.4%	57.2%
SI	92.7%	101.8%	101.2%	102.9%	108.1%	30.9%	38.7%	35.0%	29.2%	27.4%	26.8%	26.8%	26.4%
SK	127.0%	148.8%	149.1%	146.8%	159.7%	75.4%	75.6%	71.0%	68.3%	62.8%	61.9%	67.4%	71.8%
Other	**98.1%**	**114.1%**	**111.6%**	**116.7%**	**124.1%**	**65.4%**	**60.8%**	**58.7%**	**58.0%**	**53.4%**	**51.8%**	**54.5%**	**57.9%**
Total	**91.9%**	**104.3%**	**102.2%**	**105.0%**	**109.0%**	**53.1%**	**51.8%**	**48.7%**	**47.6%**	**44.9%**	**44.5%**	**47.1%**	**49.3%**

Figure 2.22 shows the ratio between cumulative allocated allowances (freely allocated and auctioned or sold) and cumulative verified emissions for each examined country in the three ETS phases. In the phase 1 some of the examined countries show surplus of freely allocated allowances compared to verified emissions, among the biggest countries Germany, Poland and France had respectively 3.2%, 14.5%, and 17% more free allowances than verified emissions. The only countries, among the biggest, without surplus of free allowances in such phase were the United Kingdom, Italy, and Spain. The overall system had 2.4% surplus. As for phase 2, when the economic crisis hit the European countries, the availability of free allowances exceeded the verified emissions in the great majority of countries. Among the biggest countries the only ones without free allowances surplus were Germany and the United Kingdom. In phase 2 the overall ETS had 2.2% of surplus. In phase 3 no country with cumulated free allowances surplus has been recorded, except Sweden and Liechtenstein. Sweden surplus of free allowances is 25%, while the allowances auctioned or sold represent 36.5% of the verified emissions. Liechtenstein surplus of free allocation is 3.24 times more than the verified emissions and the allowances auctioned or sold are 16.1 times more than the verified emissions. In the phase 3 the overall ETS free

allowances share represents 48.5% of the verified emissions, while the allowances auctioned or sold represent 46% of the verified emissions.

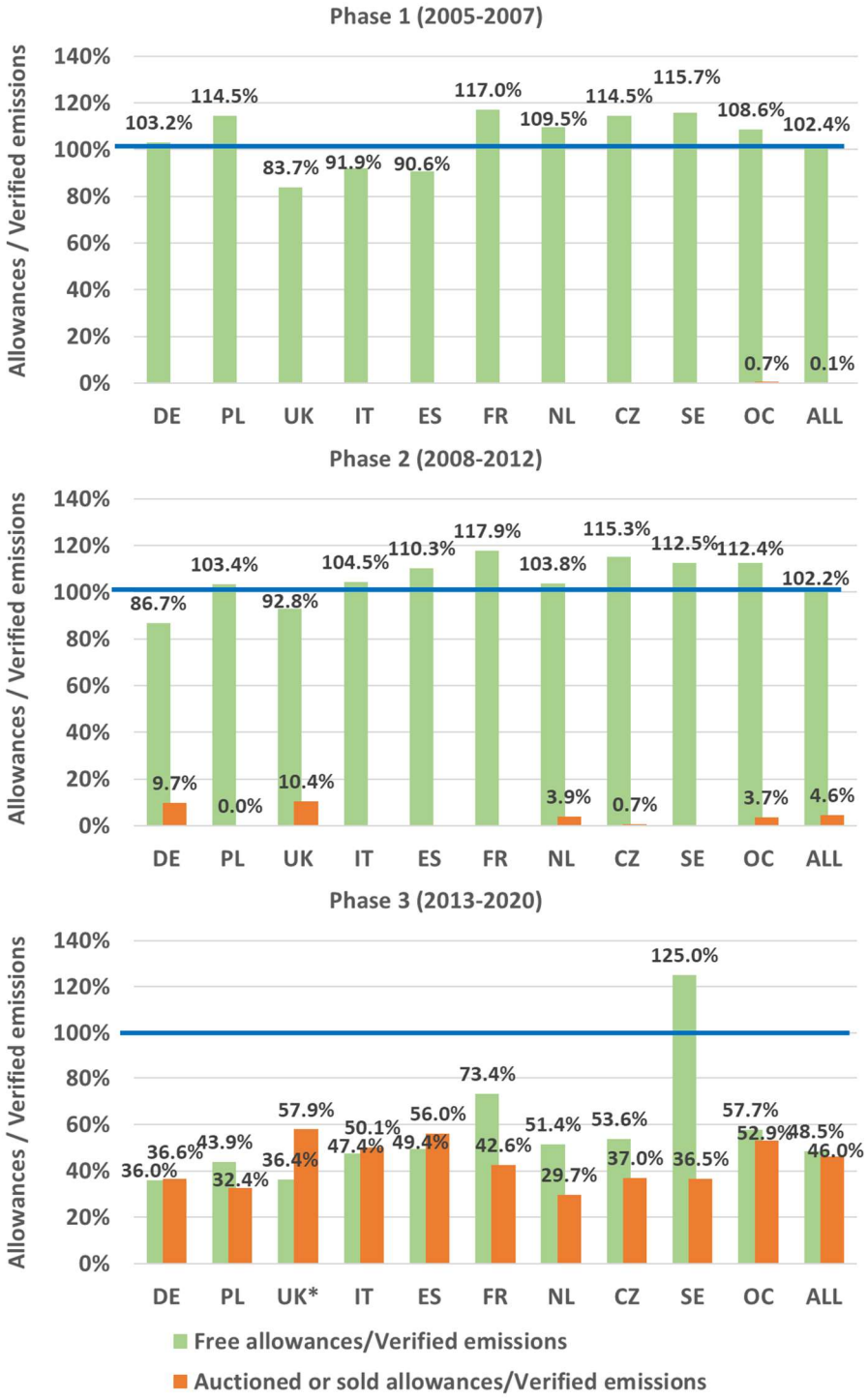


Figure 2.22 – *Percentage of cumulative allowances (freely allocated and auctioned or sold) compared to cumulative verified emissions in the three ETS phases. OC: other countries; All: all countries. Percentages for all countries include NER300 program auctioned allowances. * UK allowances auctioned or sold are not available in 2019; the cumulative data to elaborate the ratio do not consider this year for UK.*

Figure 2.23 shows the cumulative ratios for 2nd and 3rd phases for each country. At the end of last phase the only countries with surplus of cumulative freely allocated allowances compared to their

cumulative verified emissions are Liechtenstein (2.5 times more free allowances than verified emissions), Sweden (surplus of 19.4%), Latvia (surplus of 16.2%), Lithuania (surplus of 5.1%), and Romania (surplus of 2%). No one of the examined countries, except Sweden, shows surplus of free allowances, although there is a wide range of ratios from 0.57 in Germany to 0.92 in France.

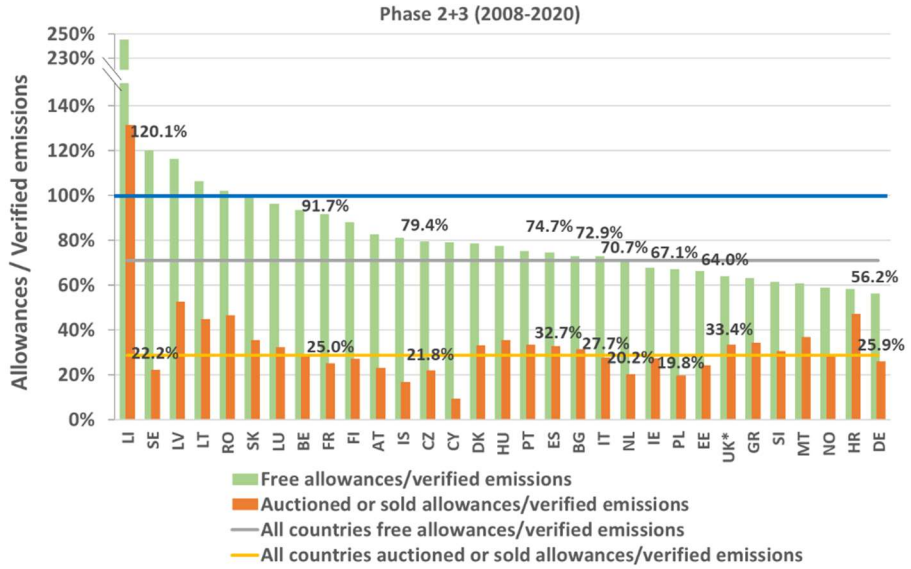


Figure 2.23 – *Percentage of cumulative allowances (freely allocated and auctioned or sold) compared to cumulative verified emissions in the ETS phases 2 and 3. Countries in descending order of ratio between free allowances and verified emissions. Labels for the examined countries are reported. * UK allowances auctioned or sold are not available in 2019; the cumulative data do not consider this year for UK.*

2.2.3 *Verified emissions and free allowances by main activity sector*

Table 2.11 and Figure 2.24 show cumulative verified emissions by main activity sector at overall level and ratio between cumulative freely allocated allowances and cumulative verified emissions in the three ETS phases. The main activity sectors accounting for at least 98% of total ETS emissions in 2020 for each country are shown. The remaining activity sectors are grouped in the item 'Other activities'.

The ratio between free allowances and verified emissions shows that many activity sectors recorded surplus of free allowances in 2nd and 3rd phases. Even in the 3rd phase relevant activity sectors such as pig iron or steel, cement clinker, bulk chemical, paper or cardboard, and non-ferrous metals recorded surplus from 2.1% to 27.5%.

Table 2.11 – *ETS emissions by main activity sector in all countries in the three phases ($MtCO_2eq$) and ratio between cumulative freely allocated allowances and cumulative verified emissions.*

Main activity sector	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
	$MtCO_2eq$			Free allowances / Verified emissions		
Combustion of fuels	4,444.8	6,999.9	8,959.3	0.98	0.90	0.21
Cement clinker	471.9	655.1	940.3	1.02	1.36	1.07
Refining of mineral oil	416.8	657.5	995.8	1.05	1.08	0.79
Pig iron or steel	425.5	636.2	988.7	1.17	1.64	1.28
Bulk chemicals	37.9	144.0	300.1	1.21	1.27	1.12
Lime, or calcination…	98.1	155.9	244.1	1.14	1.34	0.94
Ammonia	5.3	8.7	169.4	1.34	1.55	0.83
Paper or cardboard	80.9	122.4	172.9	1.20	1.33	1.11
Glass	59.6	94.7	143.2	1.11	1.23	0.84
Ceramics	45.3	56.8	111.6	1.21	1.79	0.98
Ferrous metals	28.2	31.7	103.2	1.29	2.06	0.96
Coke	44.2	65.4	88.2	1.14	1.20	0.94
Hydrogen and synth. gas	3.2	3.3	69.3	1.44	1.10	0.94
Primary aluminium	1.0	1.4	69.2	1.50	1.63	0.88
Non-ferrous metals	1.4	3.0	55.9	1.12	1.39	1.02
Other activities	50.4	73.4	187.2	1.65	1.38	1.11
All stationary installations	6,214.6	9,709.5	13,598.5	1.02	1.03	0.48
All industrial installations	1,769.8	2,709.6	4,639.2	1.12	1.36	1.02

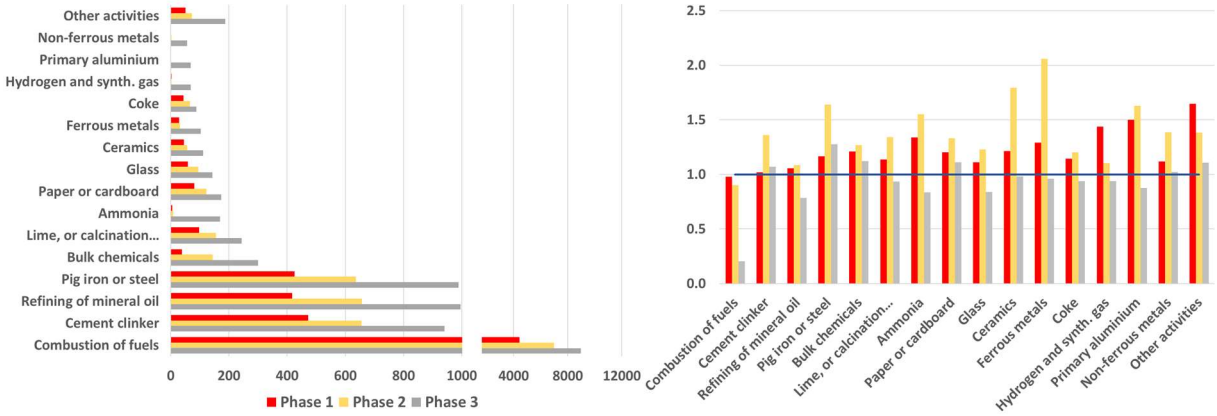


Figure 2.24 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right). The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

Figures 2.25-2.34 report sectoral emissions for the three ETS phases and ratios between free allowances and verified emissions in the examined countries and group of other countries. Each country have activity sectors with ratios higher than 1 and therefore with free allowances higher than verified emissions.

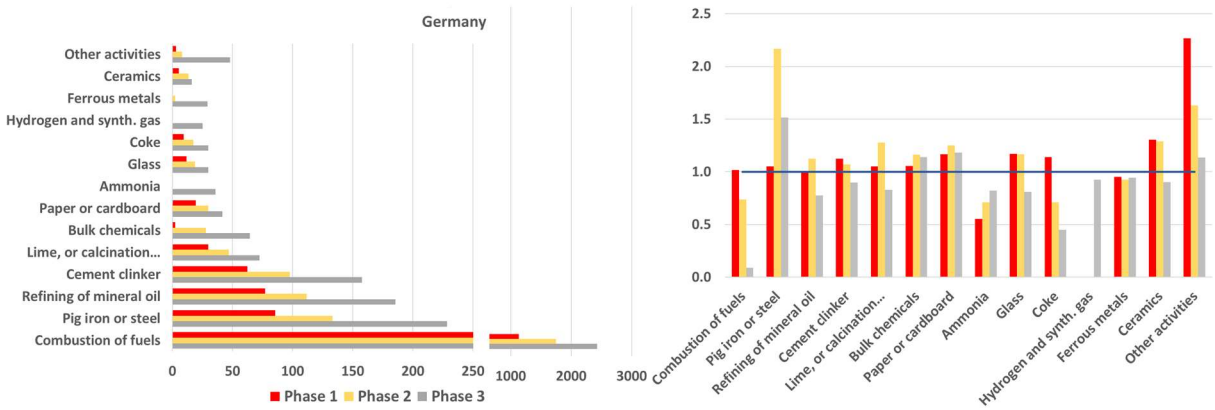


Figure 2.25 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in Germany. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

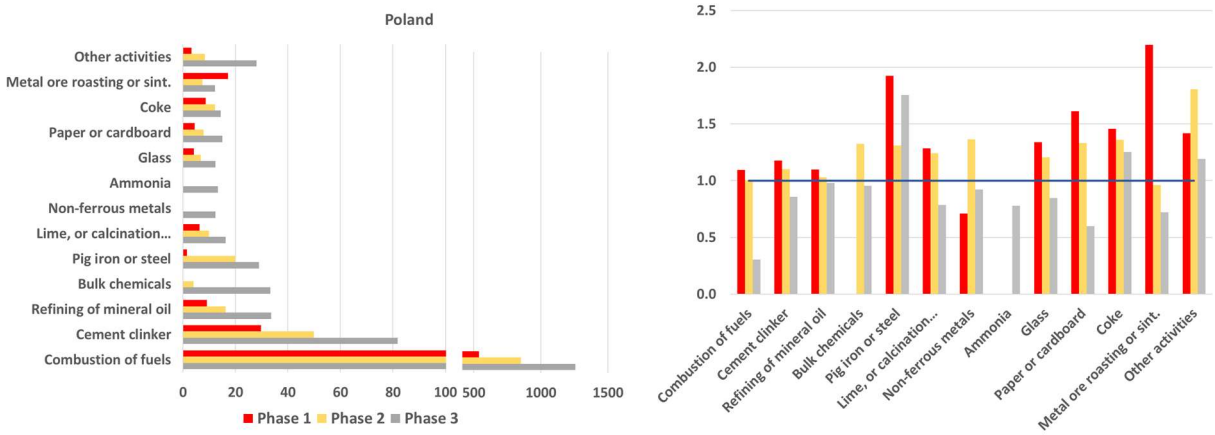


Figure 2.26 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in Poland. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

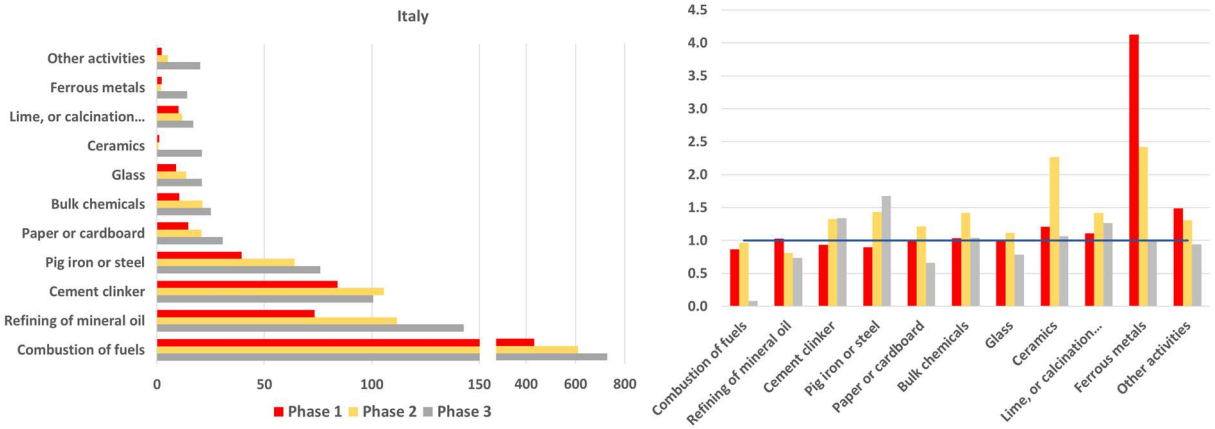


Figure 2.27 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in Italy. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

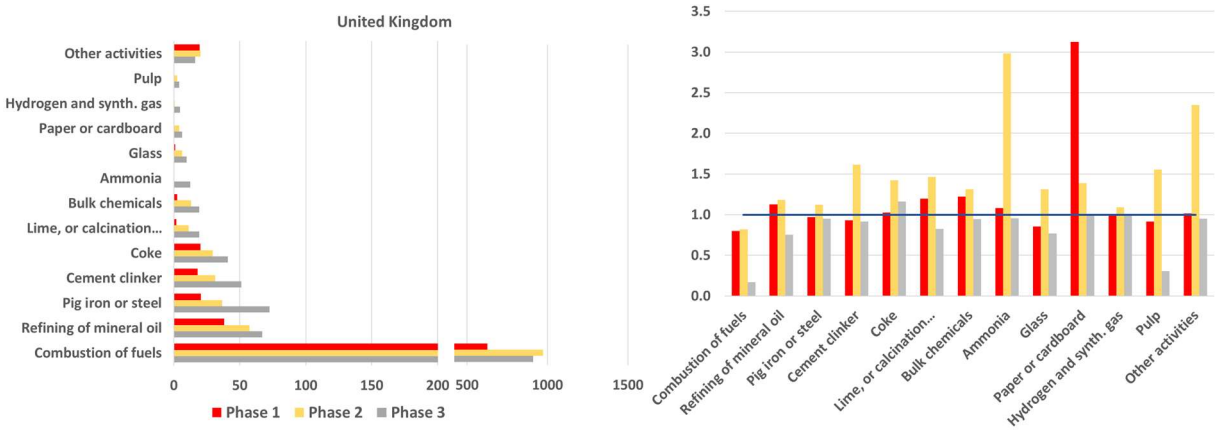


Figure 2.28 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in the UK. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

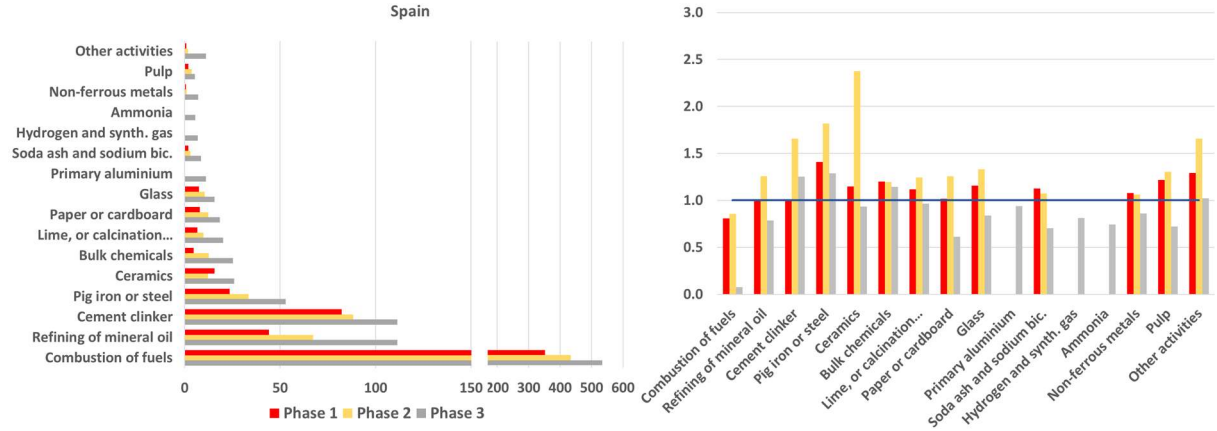


Figure 2.29 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in Spain. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

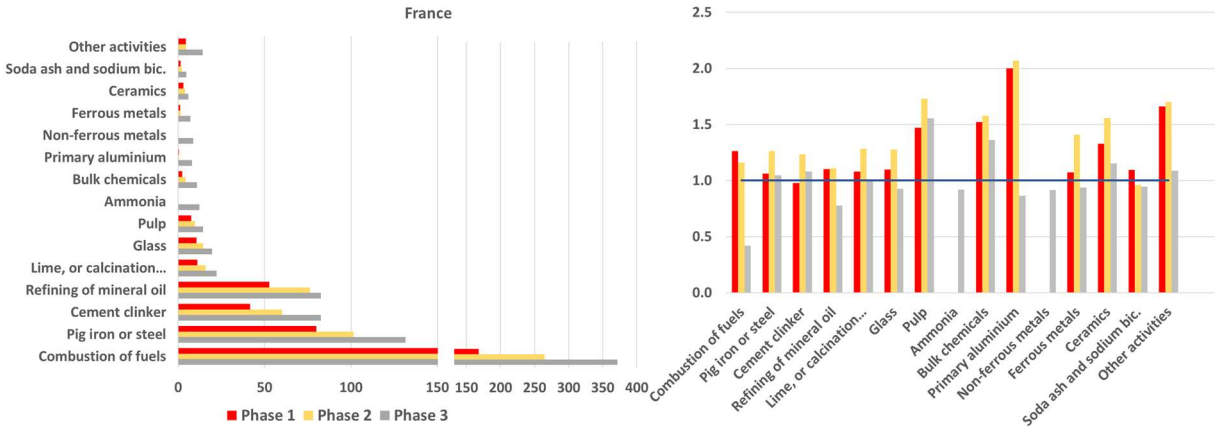


Figure 2.30 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in France. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

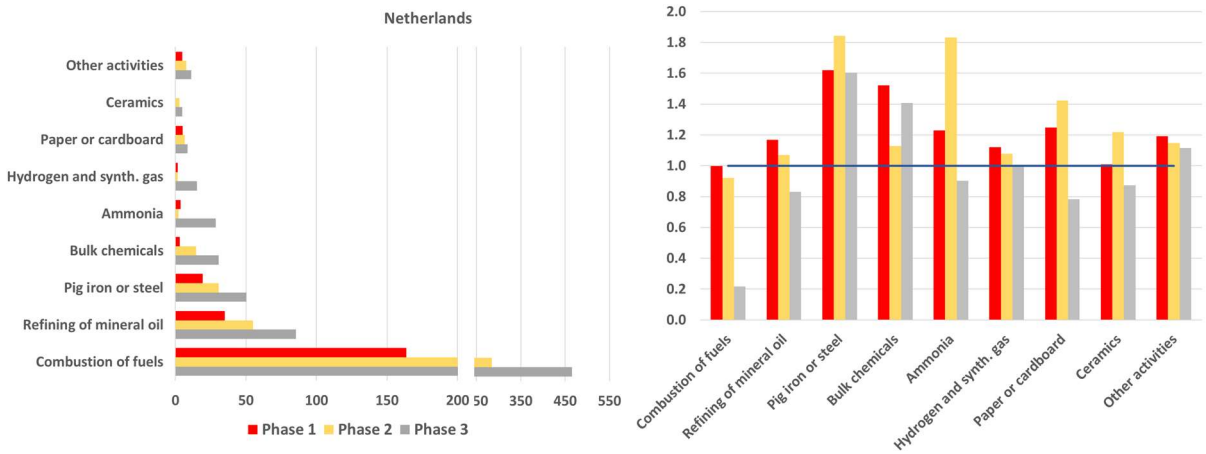


Figure 2.31 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in the Netherlands. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

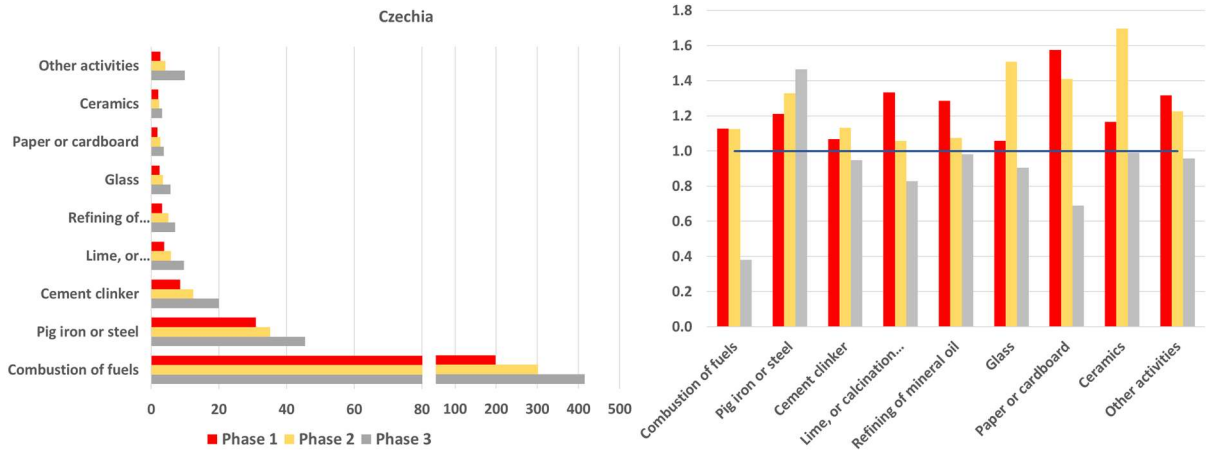


Figure 2.32 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in Czechia. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

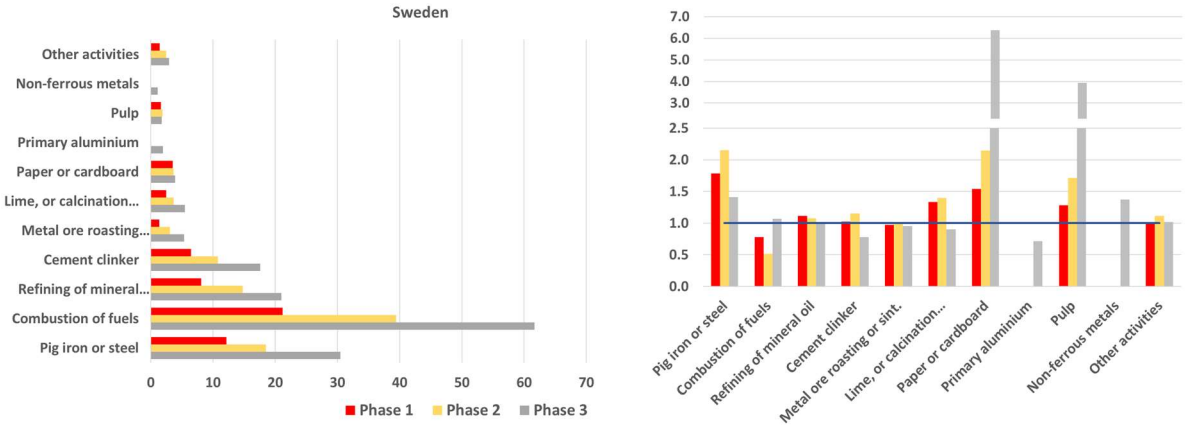


Figure 2.33 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in Sweden. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

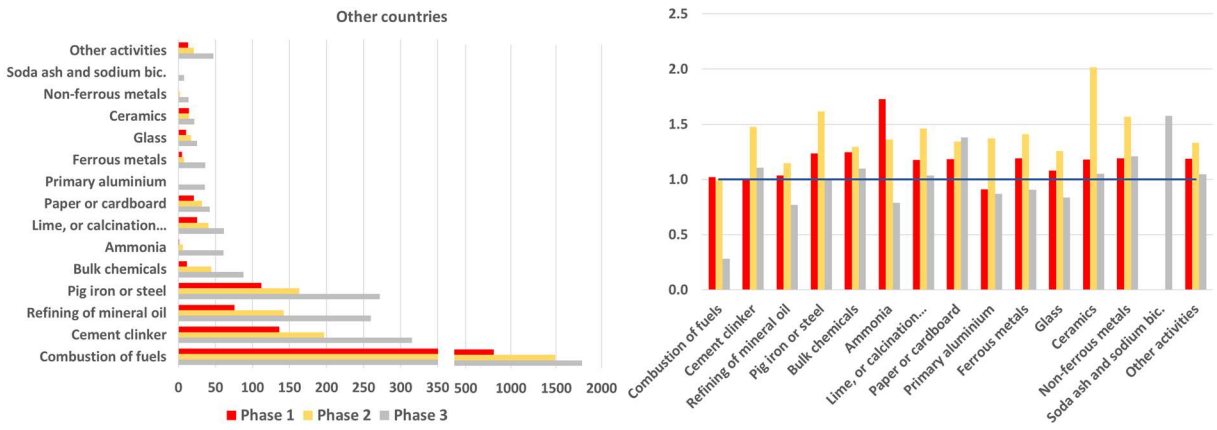


Figure 2.34 – *ETS verified emissions ($MtCO_2eq$) by main activity sector in the three phases (left) and ratio of freely allocated allowances to verified emissions by main activity sector (right) in the other countries. The main activity sectors accounting for at least 98% of ETS emissions in 2020 are shown. The remaining activity sectors are grouped in the item 'Other activities'.*

Figures 2.35-2.48 show the cumulative verified emissions in the three ETS phases by industrial activity sector and the ratio of cumulative freely allocated allowances to cumulative verified emissions in the examined countries and in the group of other countries. The activity sectors representing 96% of the overall ETS industrial emissions in 2020 are reported. The representation by sector makes countries comparable for the same sector, especially with regard to any surplus of free allowances which may depend on contingent factors that reduce production activities resulting in lower emissions than the allocated allowances.

The cement clinker sector is active in all the examined countries which account for 65.2% of the sector's emissions in 2020. Disregarding the ratio in phase 1 because of the expiring of any allocation, all the examined countries recorded surpluses of free allowances compared to verified emissions in the 2nd phase. Italy, Spain, France, and the Netherlands recorded surpluses even in the 3rd phase. The whole sector recorded surplus in all ETS countries both in 2nd and 3rd phase.

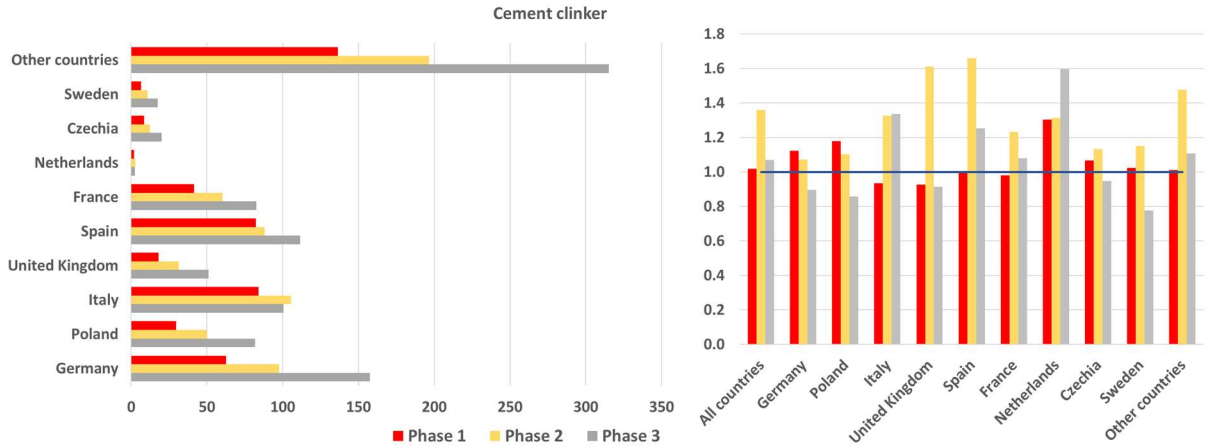


Figure 2.35 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of cement clinker in the three phases for all ETS countries, the examined countries and group of other countries.*

The emissions from refining of mineral oil sector in the examined countries account for 72.3% of the sector's total emissions in 2020. All the examined countries, except Italy, recorded relevant surpluses in the 2nd phase, while only Sweden, among the examined countries, shows a slight surplus of free allocations in the 3rd phase (+1.1%).

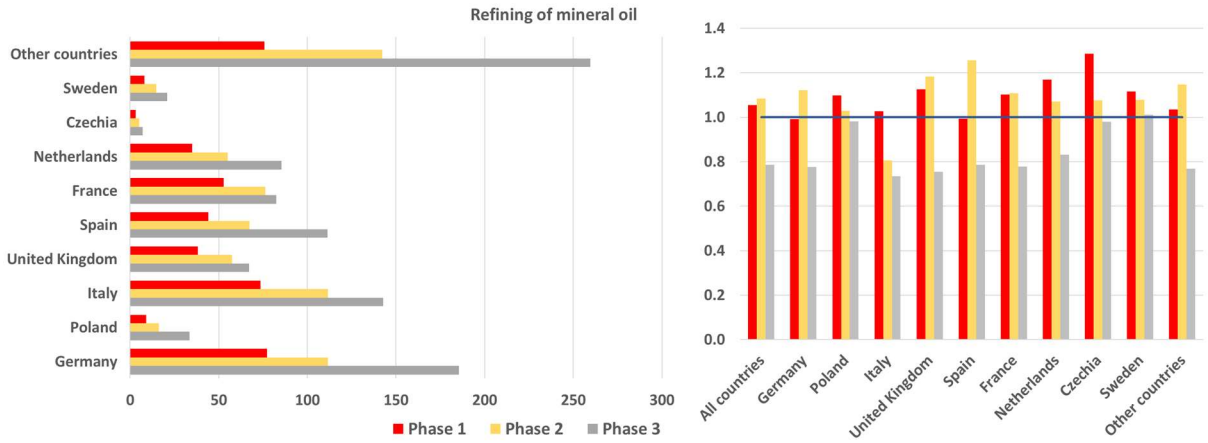


Figure 2.36 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the refining of mineral oil in the three phases for all ETS countries, the examined countries and group of other countries.*

In the examined countries the emissions from pig iron or steel sector account for 72.2% of sector's emissions in 2020. In the 2nd phase all the examined countries recorded relevant surpluses of free allowances with Germany and Sweden ratios higher than 2.1, while the surpluses for the other examined countries range from 12.2% in the UK to 84.3% in the Netherlands. Only the United Kingdom does not record surplus in the 3rd phase, while the other examined countries recorded surpluses from 4.8% (France) to 75.5% (Poland).

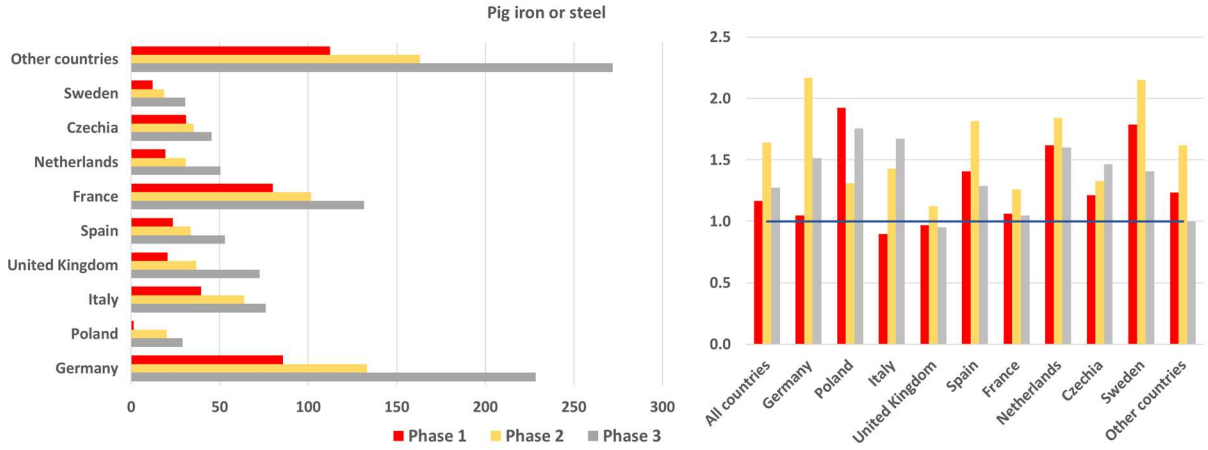


Figure 2.37 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of pig iron or steel in the three phases for all ETS countries, the examined countries and group of other countries.*

The emissions from bulk chemicals in the examined countries account for 69.8% of emissions of the sector in 2020. In the 2nd phase all the examined countries recorded surpluses, from 6.8% in Czechia to 57.5% in France. Sweden had not this sector in the 2nd phase. For the 3rd phase only Poland, the United Kingdom, and Czechia do not show surplus of free allowances, while all the other examined countries recorded surpluses, from 3.7% for Italy to the top ratio for Sweden with free allowances 2.8 times the verified emissions.

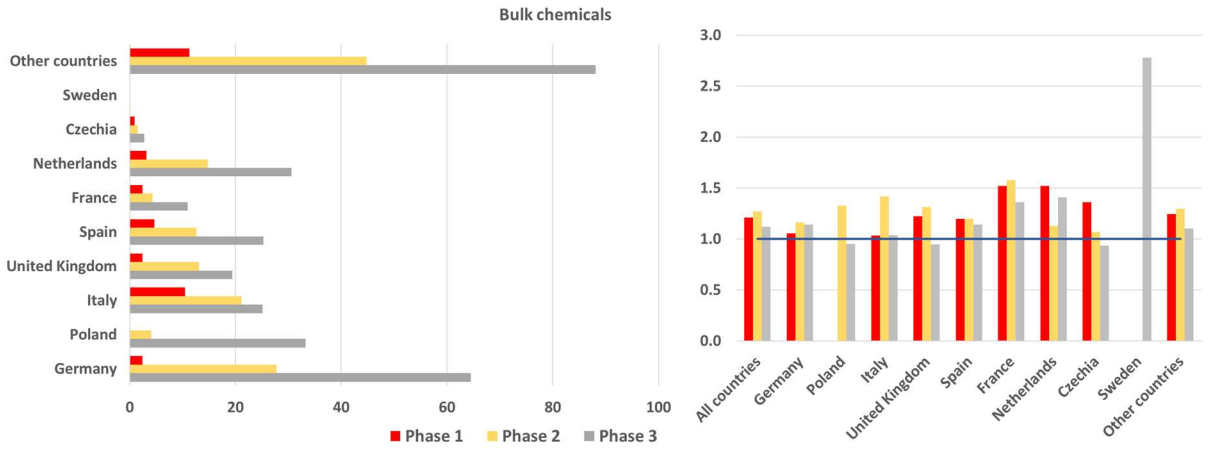


Figure 2.38 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of bulk chemicals in the three phases for all ETS countries, the examined countries and group of other countries.*

The emissions for production of lime, or calcination of dolomite/magnesite in the biggest countries account for 75.8% of the sector's emissions in 2020. In the 2nd phase stands out the ratio for the Netherlands higher than 30 although referring to very low emissions level. The surpluses for the 2nd phase in the other examined countries range from 5.7% in Czechia to 46.3% in the United Kingdom, while for the 3rd phase Italy is the only country with relevant surplus in this sector (26.4%).

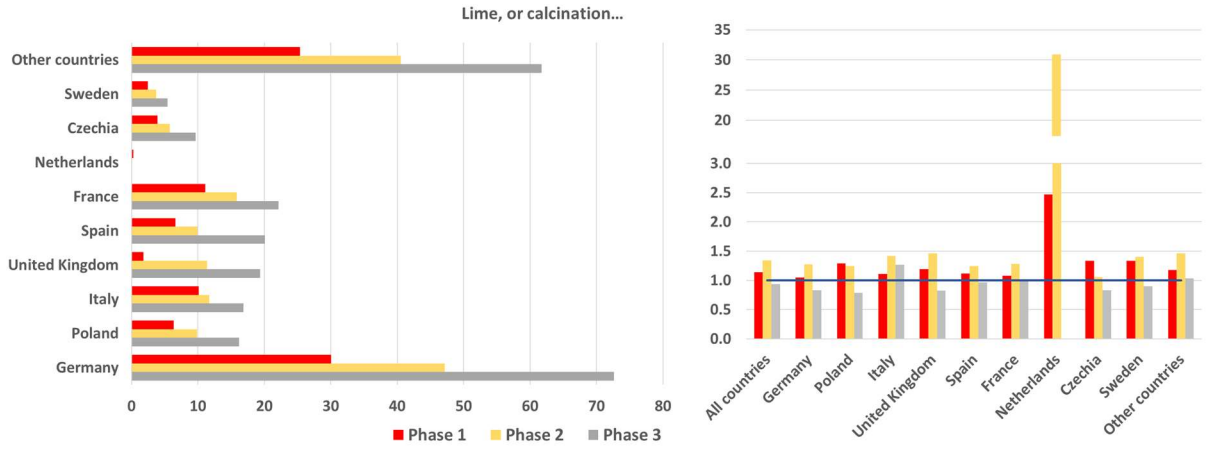


Figure 2.39 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of lime, or calcination of dolomite/magnesite in the three phases for all ETS countries, the examined countries and group of other countries.*

The production of ammonia emissions in the countries examined account for 63.8% of the sector's emissions in 2020. No surplus has been recorded for the 3rd phase, while for the 2nd one the overall sector surplus of free allocations is more than 1.5 times the verified emissions. Among the biggest countries stand out the ratios of the United Kingdom (3) and the Netherlands (1.8). In the smallest countries, where the highest share of sector's emissions occur, has been recorded 36.1% of collective free allocations surplus.

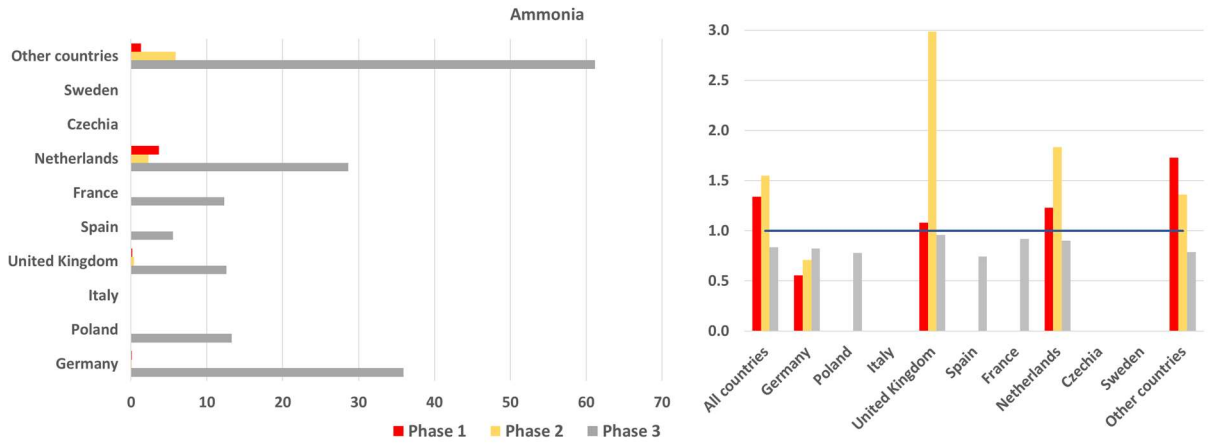


Figure 2.40 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of ammonia in the three phases for all ETS countries, the examined countries and group of other countries.*

The countries considered account for 75.1% of paper or cardboard sector's emissions in 2020. In the 2nd phase all the countries registered surpluses ranging from 21.2% in Italy to more than 2.1 times free allowances than verified emissions in Sweden. In the 3rd phase the surplus of free allowances is particularly high in Sweden with more than 6.3 times free allowances than verified emissions. The United Kingdom, Germany, and France registered surpluses of respectively 0.8%, 18.2%, and 39.3%.

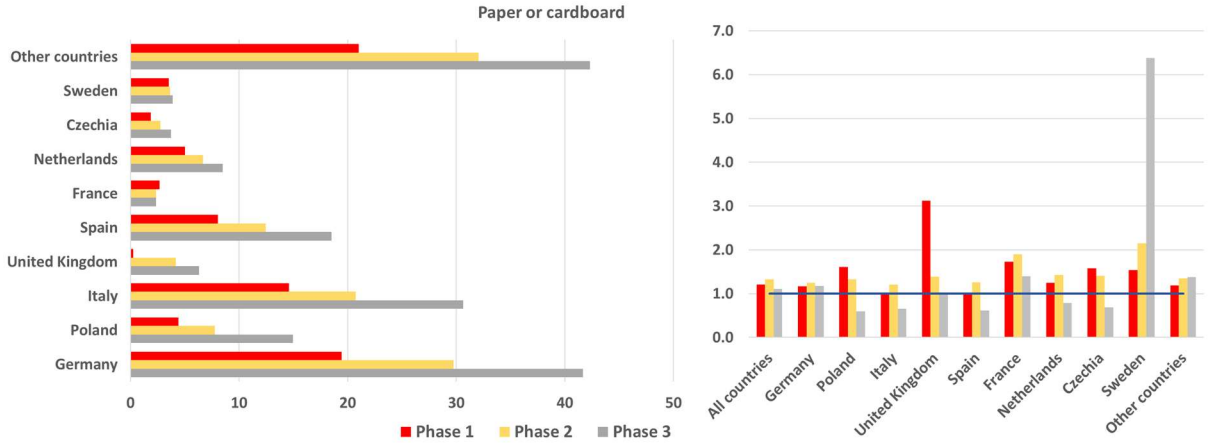


Figure 2.41 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of paper or cardboard in the three phases for all ETS countries, the examined countries and group of other countries.*

The countries considered account for 83.2% of manufacture of glass sector's emissions in 2020. Such sector show surpluses in the 2nd phase for all the considered countries ranging from 11.3% in Italy to 50.8% in Czechia. For the 3rd phase only Sweden show a surplus of 1.4%.

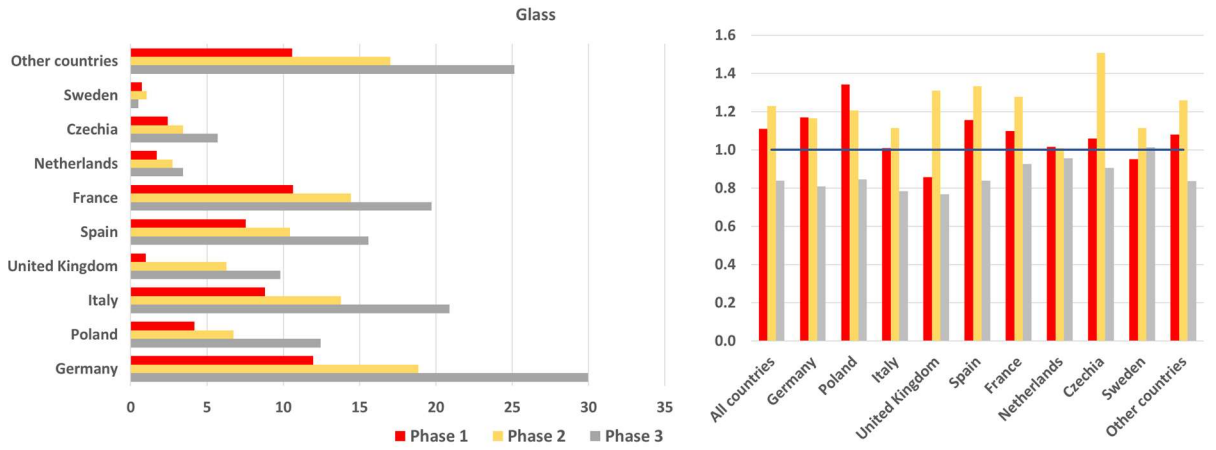


Figure 2.42 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the manufacture of glass in the three phases for all ETS countries, the examined countries and group of other countries.*

The countries considered account for 80.2% of manufacture of ceramics sector's emissions in 2020. The sector show relevant surpluses in the 2nd phase for all the considered countries, except for Sweden. The countries with surplus have ratios between free allowances and verified emissions ranging from 21.9% in the Netherlands to more than 2.4 times free allowances than verified emissions in Spain and 2.3 times in Italy. For the 3rd phase surpluses have been recorded in Italy (6.5%), France (15.3%), and Sweden (22.5%).

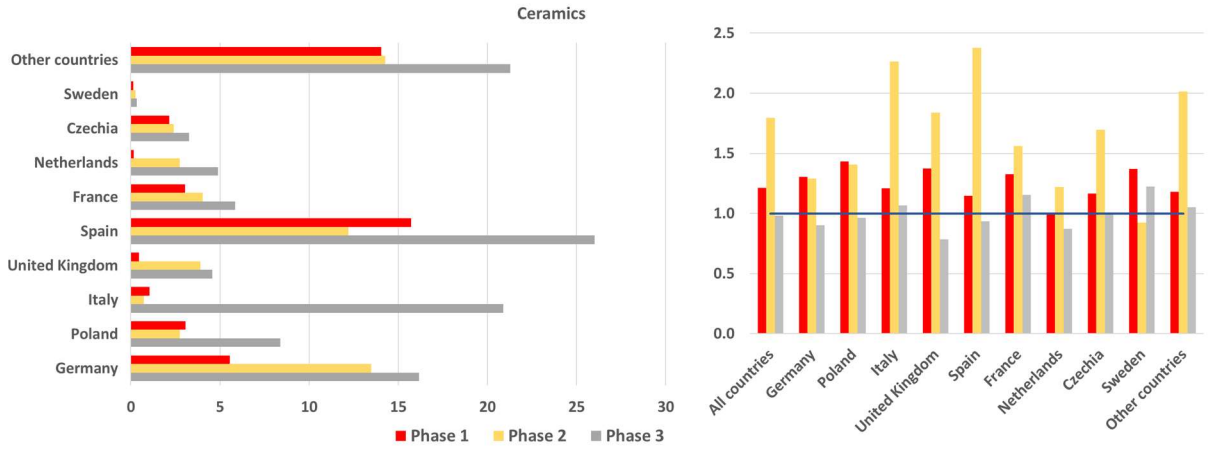


Figure 2.43 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the manufacture of ceramics in the three phases for all ETS countries, the examined countries and group of other countries.*

The examined countries account for 61.9% of ferrous metals sector's emissions in 2020. This sector is not active in the Netherlands and show relevant surpluses in the 2nd phase for all the considered countries, except for Germany. The countries with surplus of free allowances have ratios ranging from 25.2% in Sweden to more than 2.7 times free allowances than verified emissions in the UK and 2.4 times in Italy. In the 3rd phase surpluses have been recorded in Italy (6.5%), France (15.3%), and Sweden (22.5%).

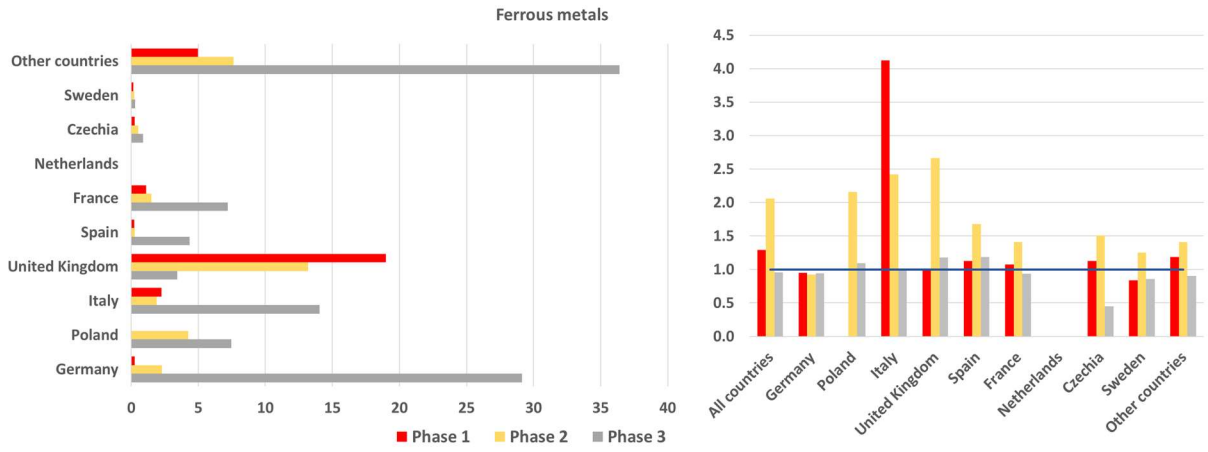


Figure 2.44 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production or processing of ferrous metals in the three phases for all ETS countries, the examined countries and group of other countries.*

The examined countries account for 98.5% of coke sector's emissions in 2020, mainly from Germany and the UK. Relevant surpluses have been recorded both for 2nd and 3rd phases, except in Germany. In the 2nd phase surpluses range from 36% in Poland to 67.6% in Czechia. In the 3rd phase surpluses range from 15.9% in the UK to 85.8% in Spain.

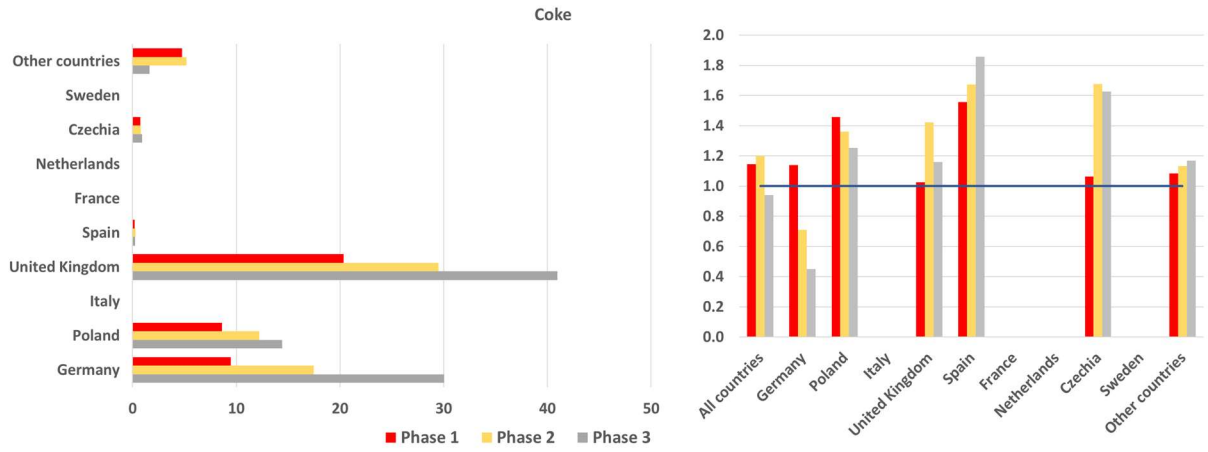


Figure 2.45 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of coke in the three phases for all ETS countries, the examined countries and group of other countries.*

The emissions for the production hydrogen and synthesis gas in the examined countries account for 86% of sector's emissions in 2020. In the 2nd phase surpluses range from 1.2% in France to 9.2% in the UK. In the 3rd phase has been recorded a surplus of 0.5% only for the UK.

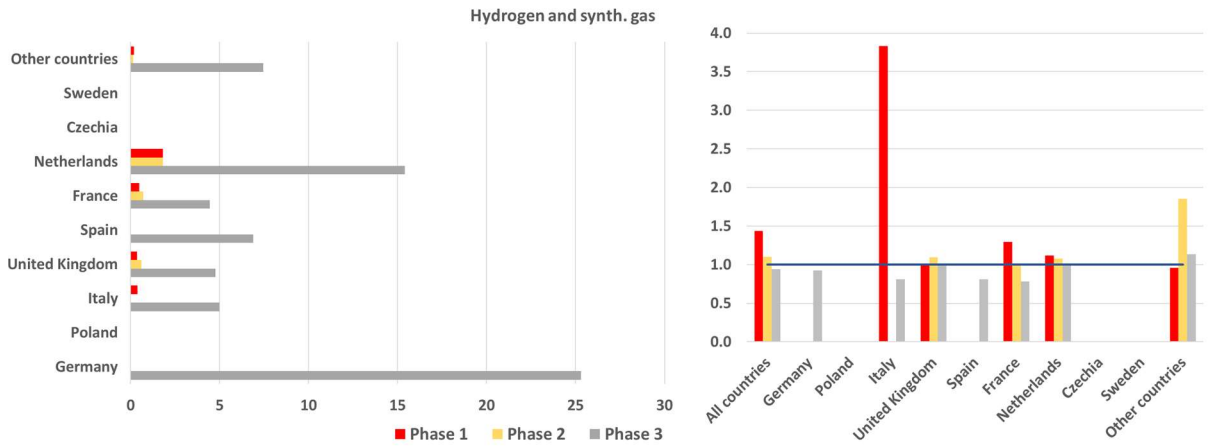


Figure 2.46 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of hydrogen and synthesis gas in the three phases for all ETS countries, the examined countries and group of other countries.*

The emissions for the production of primary aluminium in the examined countries account for 46.6% of sector's emissions in 2020. This sector is consistently active in Norway and Iceland where sector's emissions account for 27.9% and 16.4% respectively of sector's emissions in 2020. In the 3rd phase stands out the surplus recorded for Italy, with free allowances more than 6747 times the verified emissions.

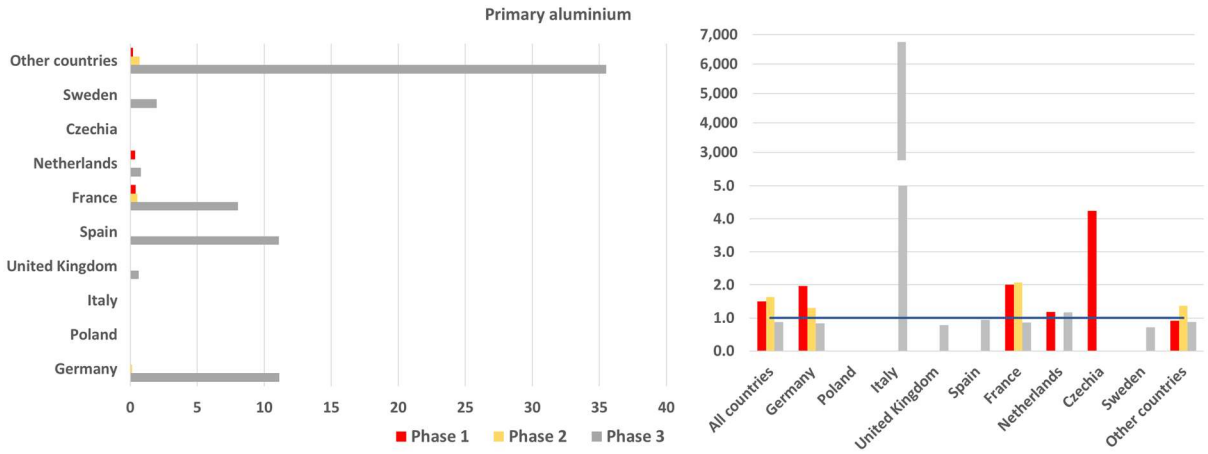


Figure 2.47 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production of primary aluminium in the three phases for all ETS countries, the examined countries and group of other countries.*

The examined countries account for 73% of non-ferrous metals sector's emissions in 2020. In the 2nd phase the surpluses range from 5.9% in Spain to 36.4% in Poland. In the 3rd phase have been recorded surpluses of free allowances only for the Netherlands and Sweden, respectively more than 3.7 and 1.4 times the verified emissions.

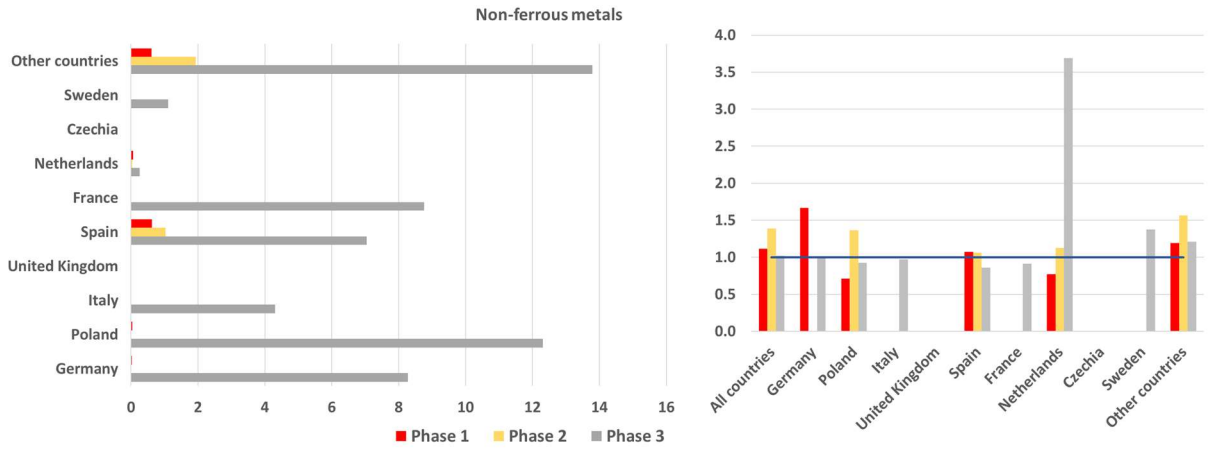


Figure 2.48 – *ETS verified emissions ($MtCO_2eq$; left) and ratio of freely allocated allowances to verified emissions (right) for the production or processing of non-ferrous metals in the three phases for all ETS countries, the examined countries and group of other countries.*

2.2.4 *Deficit/surplus of freely allocated allowances from 2008 to 2020*

The allowances allocated during the 1st EU-ETS phase expired at the transition to phase 2. Phase 2 coincided with the first Kyoto period and the allowances were linked to the assigned amount units (AAU) as they were functional to the Kyoto reduction targets: in 2008, therefore, allowances from the previous phase could not circulate, which were therefore cancelled so as not to be accounted for the Kyoto Protocol targets. Starting with phase 3 the EU-ETS has been separated from Kyoto and allowances, functional to European policy reduction targets, can be capitalised from one phase to the next (banking). All not surrendered allowances for the compliance process can be sold on the market.

The ratio between freely allocated allowances and verified emissions since 2008 to 2020 allows to assess the overall deficit/surplus of cumulative free allowances. As already stated, the rationale behind free allocation of allowances is to ensure the competitiveness of industrial sectors exposed to the carbon leakage yet any deficit/surplus of free allowances interferes with carbon price market. It is not the aim of this work to assess such effect but the analysis focuses on the amount of deficit/surplus of free allowances by country and main activity sector in the examined countries.

Figure 2.49 shows the percentage of cumulative free allowances compared to the verified emissions for each country in the period 2008-2020. The free allowances in Germany are 56.2% of the emissions. The percentage for Italy is 72.9%. At the other end there are countries with percentages greater than 100%, in other words with more cumulated free allowances than the verified emissions.

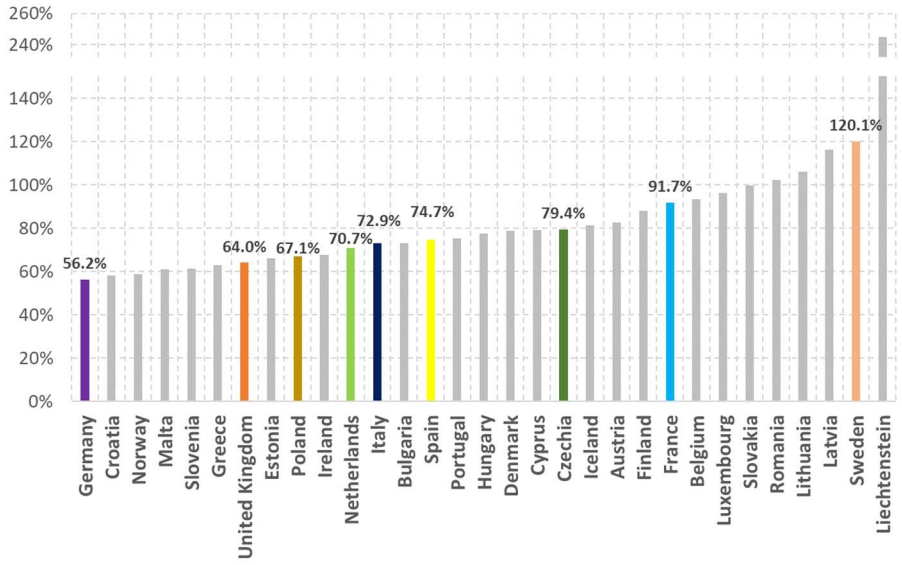


Figure 2.49 – *Percentage of cumulative free allowances compared to cumulative verified emissions from 2008 to 2020. Examined countries (coloured bars) account for 77.5% of ETS cumulative verified emissions in the period.*

The percentage of free allowances may be more usefully read in terms of deficit or surplus of allowances, i.e. verified emissions to be offset by allowances available on market (deficits) or greater availability of free allowances than verified emissions (surplus). Countries with negative percentages have a deficit of free allowances, while countries with positive percentages have a surplus of free allowances.

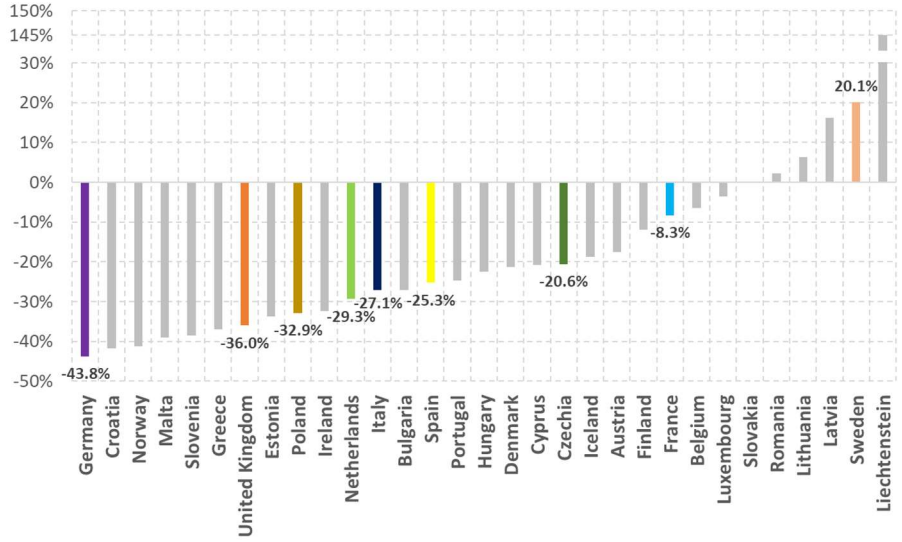


Figure 2.50 – *Cumulative free allowance deficit (negative values) / surplus (positive values) over the period 2008-2020.*

Considering only industrial installations (Figure 2.51), whose ratio of free allowances to verified emissions at overall level is close to 1 in the 3rd phase but much higher than 1 in the previous phase (see Figure 2.20), it is possible noting a wide range of deficit/surplus between countries and, among the examined ones, surpluses range from 6.4% in Poland and 43.6% in Sweden.

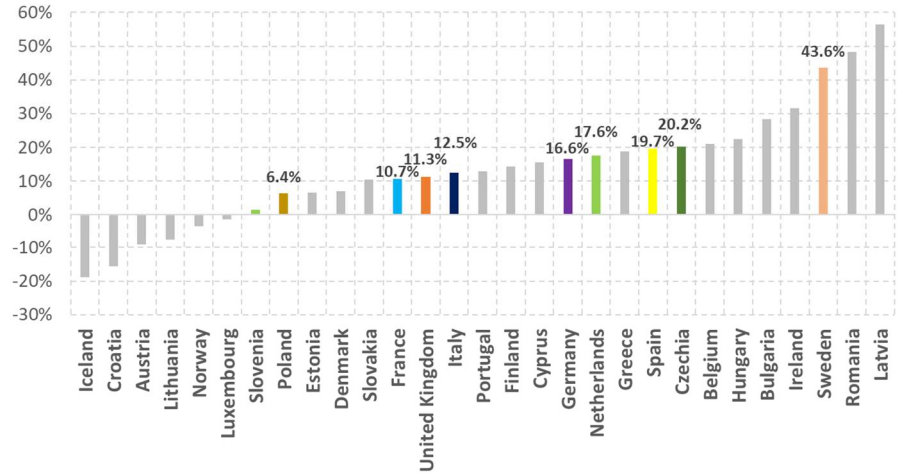


Figure 2.51 – *Cumulative free allowance deficit (negative values) / surplus (positive values) over the period 2008-2020 for industrial installations.*

Combustion of fuels installations (Figure 2.52), that since 2013 do not have free allowances for electricity production, registered deficits ranging from -14.8% in Sweden to -63.9% in Germany.

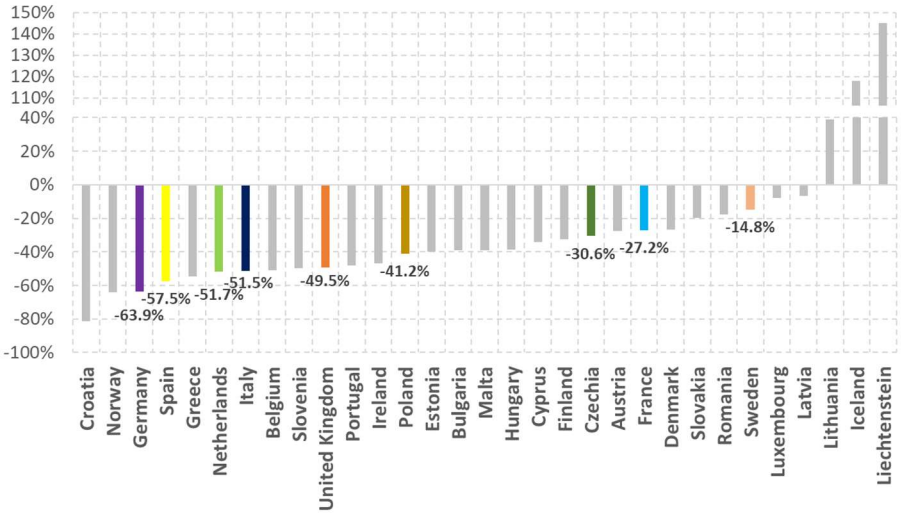


Figure 2.52 – *Cumulative free allowance deficit (negative values) / surplus (positive values) over the period 2008-2020 for combustion of fuels installations.*

Table 2.12 summarizes cumulative emissions and free allowances since 2008 with the relative surplus/deficit for all stationary installations, combustion of fuels and industrial installations in the considered countries, in the group of other countries and all countries. For the industrial installations all the examined countries recorded surpluses of free allowances compared to verified emissions.

Table 2.12 – *Cumulative verified emissions and cumulative free allowances ($MtCO_2eq$) in the period 2008-2020. Deficit/surplus of free allowances and % compared to cumulative emissions is also reported.*

Activity	Countries	Verified emissions 2008-2020	Free allowances 2008-2020	Deficit/surplus	% deficit/surplus
All stationary installations*	Germany	5,653.8	3,180.0	-2,473.8	-43.8%
	Poland	2,551.8	1,712.8	-839.0	-32.9%
	United Kingdom	2,422.9	1,550.8	-872.1	-36.0%
	Italy	2,163.1	1,576.6	-586.4	-27.1%
	Spain	1,660.9	1,240.8	-420.1	-25.3%
	France	1,356.9	1,244.6	-112.3	-8.3%
	Netherlands	1,106.4	781.7	-324.7	-29.3%
	Czechia	892.9	709.0	-184.0	-20.6%
	Sweden	251.4	301.9	50.5	20.1%
	Other countries	5,247.9	4,217.6	-1,030.2	-19.6%
	All countries	**23,308.0**	**16,516.0**	**-6,792.0**	**-29.1%**
Combustion of fuels	Germany	4,181.5	1,511.0	-2,670.5	-63.9%
	Poland	2,108.2	1,240.5	-867.7	-41.2%
	United Kingdom	1,885.1	952.5	-932.6	-49.5%
	Italy	1,338.6	649.1	-689.6	-51.5%
	Spain	967.9	411.5	-556.4	-57.5%
	France	636.6	463.5	-173.1	-27.2%
	Netherlands	749.8	362.4	-387.3	-51.7%
	Czechia	716.9	497.4	-219.5	-30.6%
	Sweden	101.1	86.2	-14.9	-14.8%
	Other countries	3,273.5	1,975.5	-1,298.0	-39.7%
	All countries	**15,959.2**	**8,149.7**	**-7,809.5**	**-48.9%**
All industrial installations	Germany	1,472.2	1,717.0	244.7	16.6%
	Poland	443.7	472.3	28.6	6.4%
	United Kingdom	537.7	598.2	60.5	11.3%
	Italy	824.5	927.6	103.1	12.5%
	Spain	693.0	829.4	136.3	19.7%
	France	720.3	797.3	77.0	10.7%
	Netherlands	356.6	419.3	62.7	17.6%
	Czechia	176.0	211.6	35.6	20.2%
	Sweden	150.3	215.7	65.5	43.6%
	Other countries	1,974.4	2,250.4	276.0	14.0%
	All countries	**7,348.8**	**8,438.8**	**1,090.0**	**14.8%**

* The free allowances total for all stationary installations does not correspond to the sum of the totals for combustion of fuels and industrial installations. Data for all stationary installations account for the corrections to freely allocated allowances (not reflected in EUTL) for Germany, France, Austria, and Denmark.

The sectoral analysis shows that the majority of industrial activity sectors have surplus of free allowances in the period 2008-2020, from 1.6% for the carbon black sector to 703.4% for the production of adipic acid. Cumulative emissions from sectors with free allowance surpluses account for 69.8% of industrial emissions. The surplus concerns sectors with high share of emissions, such as the cement clinker sector and pig iron or steel sector. Moreover, it should be pointed out that surpluses of free allowances have been recorded also for sectors entered in ETS at the 3rd phase.

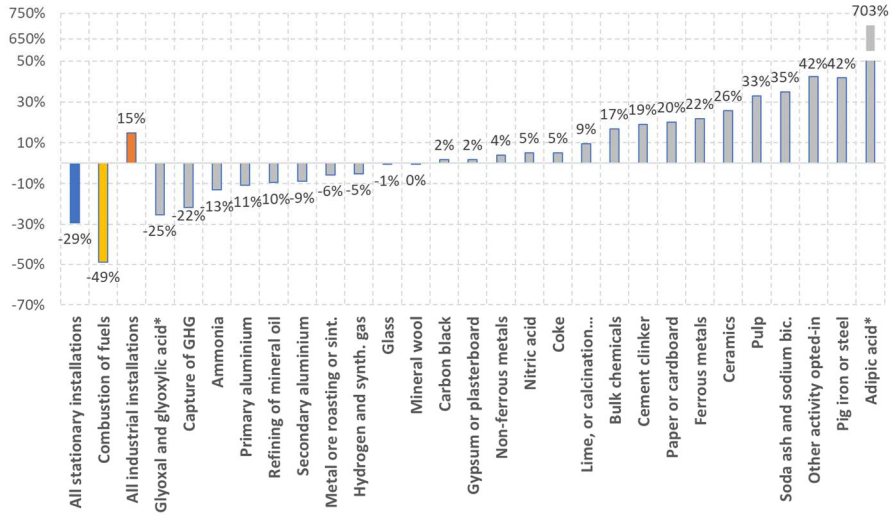


Figure 2.53 *–Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 for all stationary installations. * Activities starting in 2013.*

Such analysis can be carried out for the examined countries to highlight the industrial sectors with allocation of free allowances to avoid the carbon leakage risk. Figures 2.54-2.63 show that each country has its own sectors with surpluses, although some sectors, such as cement clinker and bulk chemicals, have surpluses in almost all the examined countries, or sector as pig iron or steel with surplus in all the examined countries, although of different sizes.

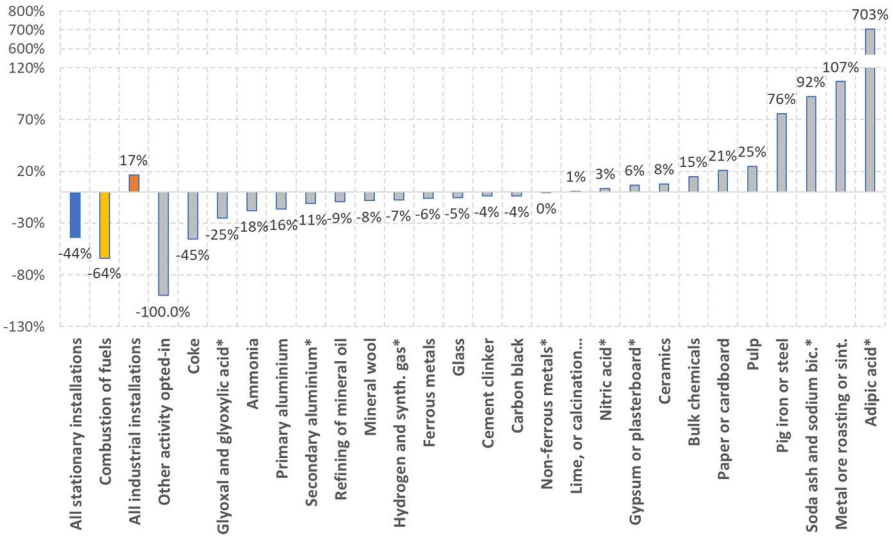


Figure 2.54 *– Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in Germany over the same period. * Activities starting in 2013.*

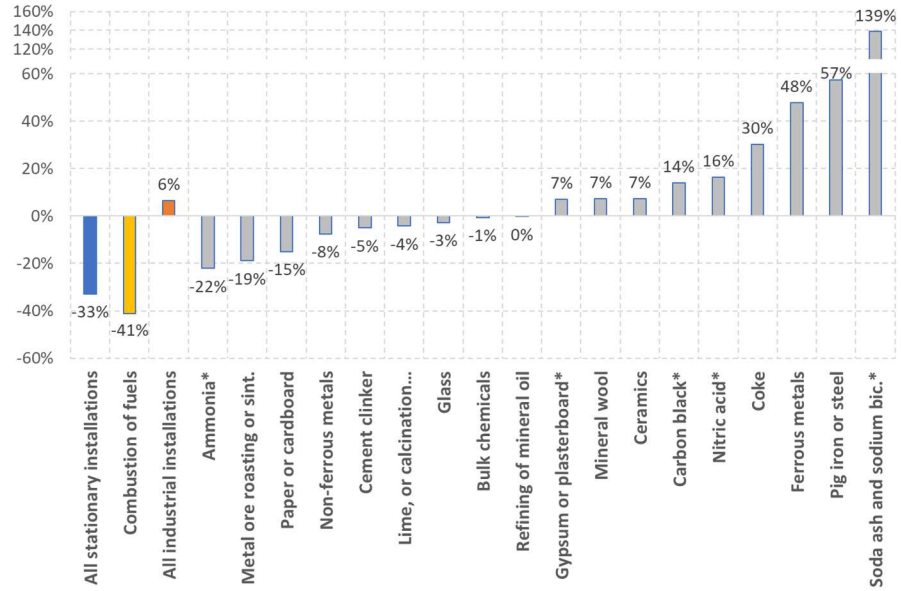


Figure 2.55 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in Poland. * Activities starting in 2013.*

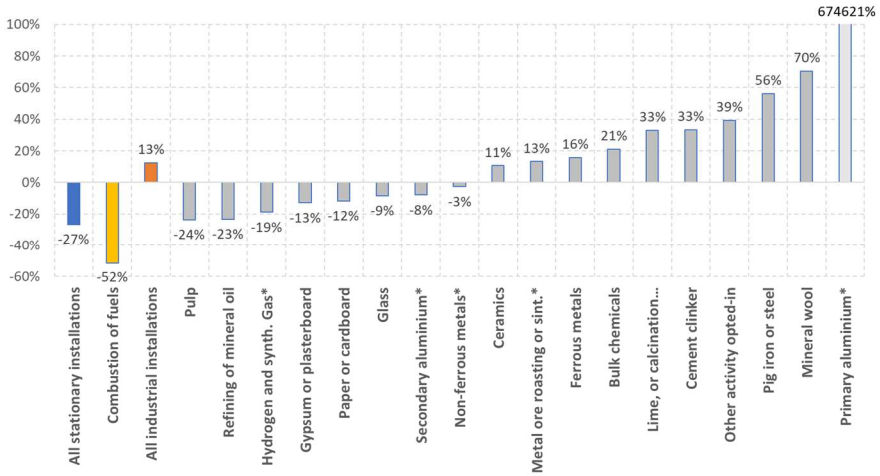


Figure 2.56 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in Italy. * Activities starting in 2013.*

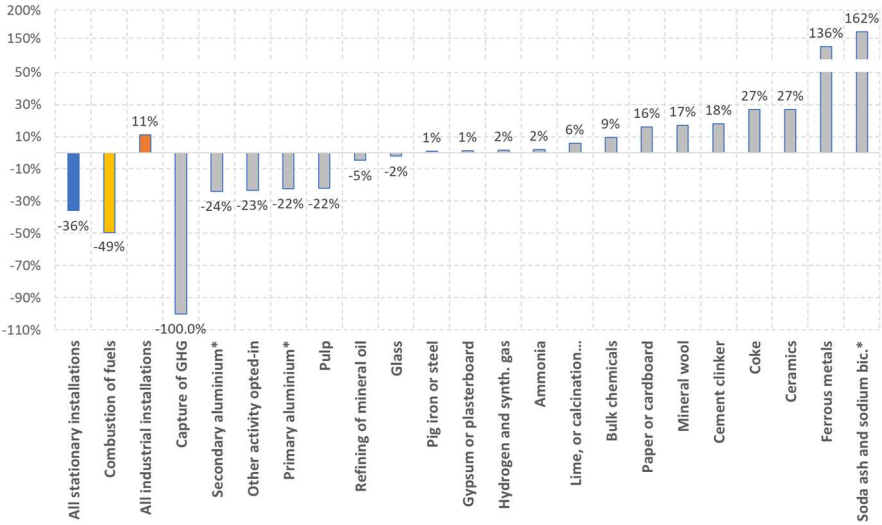


Figure 2.57 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008- in the United Kingdom. * Activities starting in 2013.*

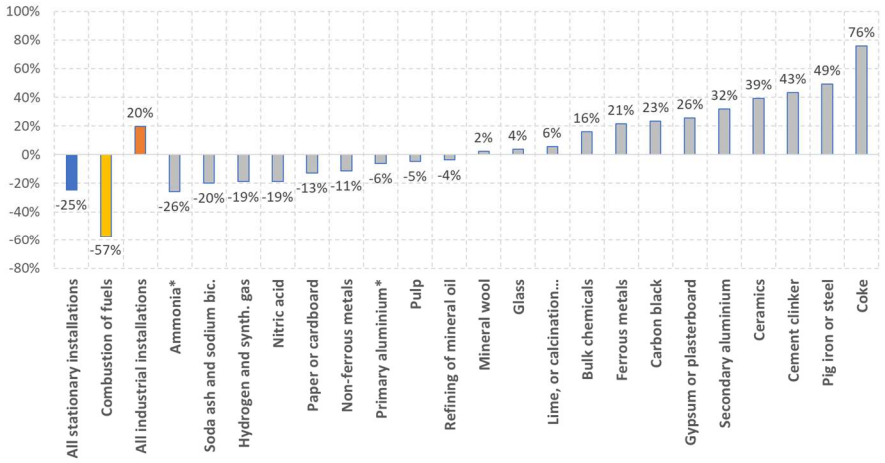


Figure 2.58 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in Spain. * Activities starting in 2013.*

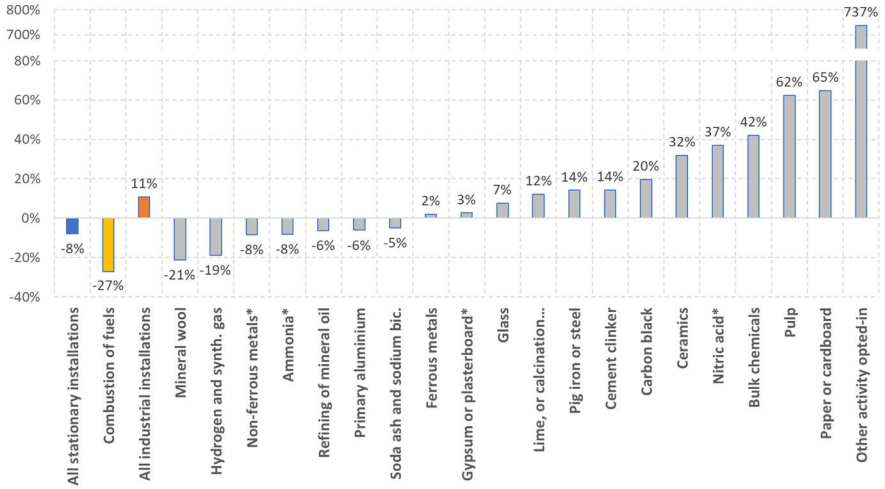


Figure 2.59 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in France. * Activities starting in 2013.*

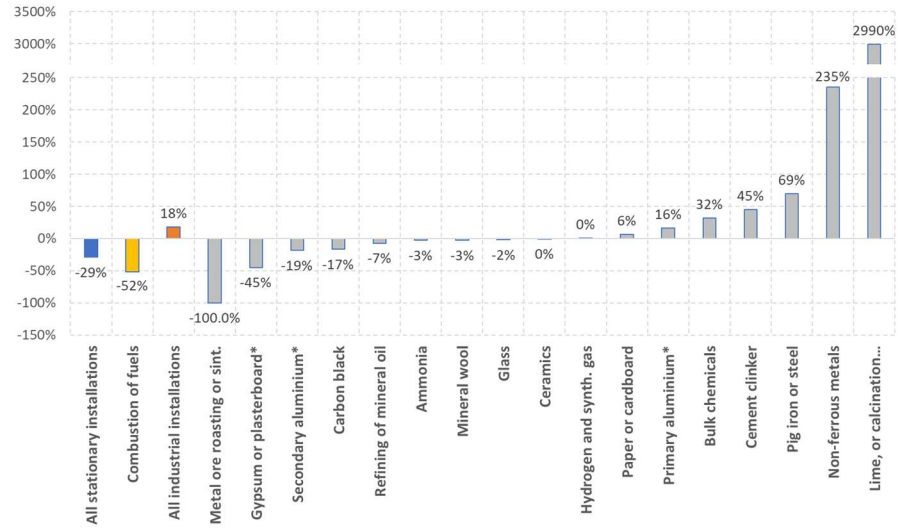


Figure 2.60 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in the Netherlands. * Activities starting in 2013.*

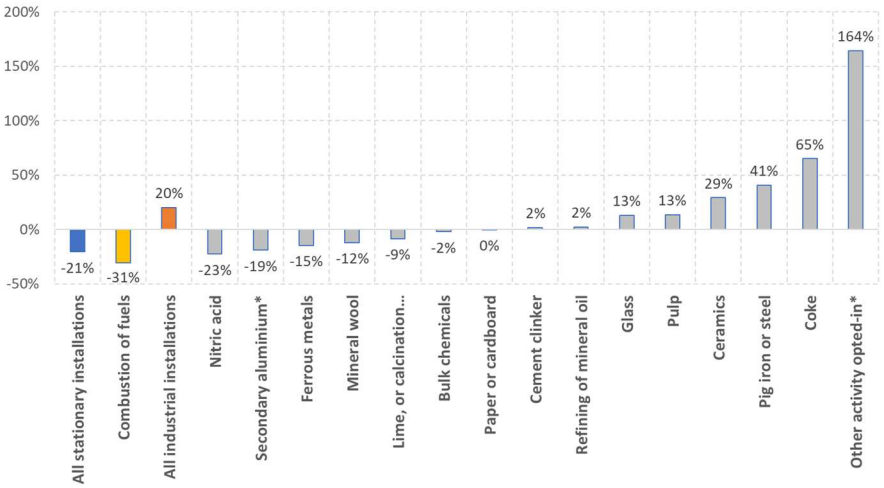


Figure 2.61 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in the Czech Republic. * Activities starting in 2013.*

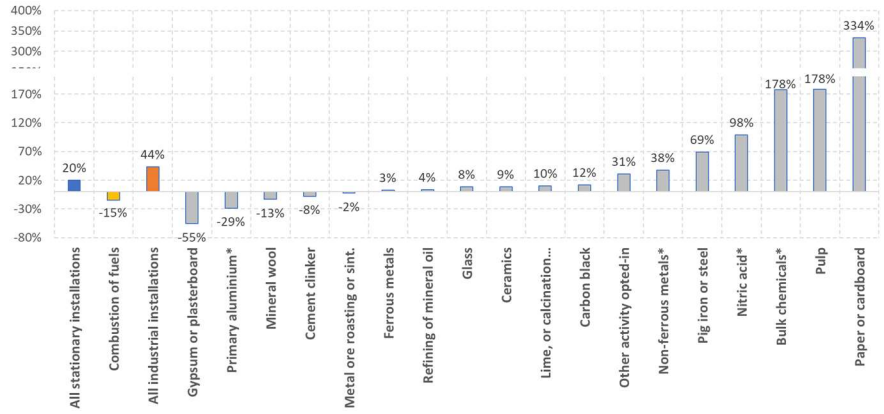


Figure 2.62 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in Sweden. * Activities starting in 2013.*

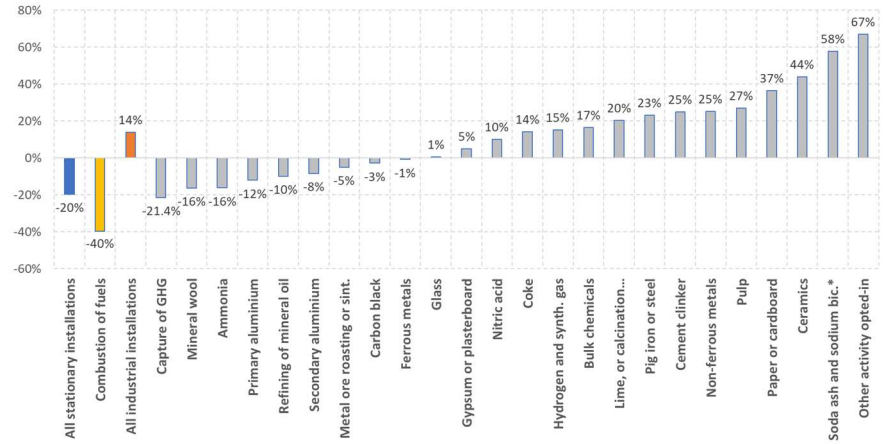


Figure 2.63 – *Deficit/surplus by sector of cumulative free allocated allowances in the period 2008-2020 in the other countries. * Activities starting in 2013.*

Figure 2.64 shows deficit or surplus by country recorded for the most relevant industrial sectors in terms of emissions and surplus. The sectors have surpluses of free allowances in almost all countries and at overall level represent 61.6% of cumulative emissions from all industrial installations since 2008.

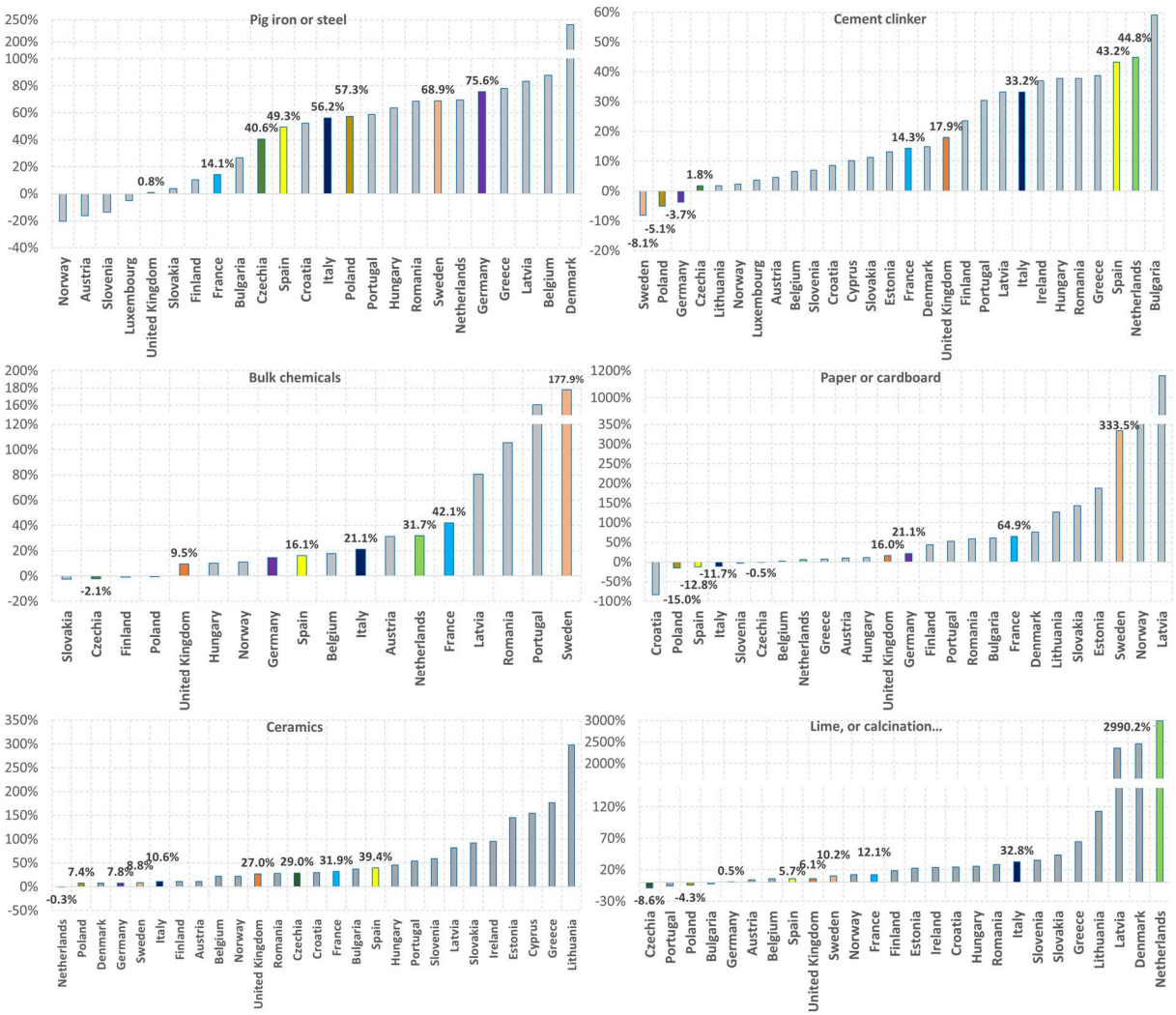


Figure 2.64 – *Deficit/surplus by sector of cumulative free allocated allowances over the period 2008-2020 by country.*

Table 2.13 shows the cumulative free allowance deficit/surplus by sector since 2008 in the examined countries, group of other countries, and all countries. Sectors with highest emission intensities are also the sectors with highest surplus of free allowances at overall level. Table 2.14 shows the percentage of the deficit/surplus compared to the cumulative verified emissions from 2008 to 2020.

Table 2.13 – *Cumulative free allocated allowances deficit/surplus by main activity ($MtCO_2eq$) over the period 2008-2020 in the examined countries, the group of other countries and all countries. Industrial sectors in decreasing order of total deficit/surplus.*

Activity	DE	PL	UK	IT	ES	FR	NL	CZ	SE	Other	All
Pig iron or steel	273.2	28.1	0.9	78.8	42.6	32.9	56.3	32.7	33.7	100.2	679.4
Cement clinker	-9.5	-6.7	14.8	68.5	86.2	20.4	2.3	0.6	-2.3	127.2	301.6
Bulk chemicals	13.5	-0.2	3.1	9.8	6.1	6.4	14.4	-0.1	0.0	22.1	75.0
Paper or cardboard	15.1	-3.4	1.7	-6.0	-4.0	3.1	1.0	-0.0	25.2	27.2	59.8
Ceramics	2.3	0.8	2.3	2.3	15.1	3.1	-0.0	1.6	0.1	15.6	43.2
Lime, or calcination…	0.6	-1.1	1.9	9.4	1.7	4.6	0.2	-1.3	0.9	20.9	37.8
Ferrous metals	-1.9	5.6	22.5	2.5	1.0	0.2		-0.2	0.0	-0.3	29.4
Pulp	1.1		-1.4	-1.7	-0.4	15.1		0.1	6.5	4.9	24.1
Soda ash and sodium bic.	4.0	4.5	2.0		-2.3	-0.3				4.5	12.3
Adipic acid	7.1									0.0	7.1
Coke	-21.6	8.1	19.0		0.4			1.1		1.0	7.9
Other activity opted-in	-0.0		-0.7	2.3		0.8		0.9	0.0	1.7	5.0
Non-ferrous metals	-0.0	-0.9		-0.1	-0.9	-0.7	0.7		0.4	4.0	2.4
Nitric acid	0.2	0.8			-0.8	1.1		-1.1	0.3	1.6	1.9
Carbon black	-0.3	0.1			0.3	0.7	-0.5		0.1	-0.1	0.3
Gypsum or plasterboard	0.1	0.1	0.0	-0.1	0.2	0.0	-0.2		-0.2	0.1	0.2
Glyoxal and glyox. acid	-0.0									0.0	-0.0
Capture of GHG			-0.0							-0.0	-0.0
Mineral wool	-0.4	0.3	0.7	0.7	0.0	-0.2	-0.1	-0.1	-0.1	-0.9	-0.1
Secondary aluminium	-0.5		-0.2	-0.1	0.2		-0.1	-0.0		-0.3	-0.9
Glass	-2.6	-0.5	-0.3	-3.0	1.0	2.5	-0.1	1.2	0.1	0.3	-1.4
Metal ore roasting or sint.	2.1	-3.7		0.0			-0.0		-0.2	-0.2	-1.9
Hydrogen and synth. gas	-1.9		0.1	-0.9	-1.3	-1.0	0.1			1.2	-3.8
Primary aluminium	-1.8		-0.1	0.2	-0.7	-0.5	0.1		-0.6	-4.4	-7.7
Ammonia	-6.5	-2.9	0.2		-1.4	-1.0	-0.9			-10.9	-23.4
Refining of mineral oil	-27.8	-0.1	-5.9	-59.5	-6.6	-10.1	-10.5	0.2	1.4	-39.4	-158.2
All industrial instal.	**244.7**	**28.6**	**60.5**	**103.1**	**136.3**	**77.0**	**62.7**	**35.6**	**65.5**	**276.0**	**1,090.0**
Combustion of fuels	**-2,670.5**	**-867.7**	**-932.6**	**-689.6**	**-556.4**	**-173.1**	**-387.3**	**-219.5**	**-14.9**	**-1,298.0**	**-7,809.5**
All stationary instal.*	**-2,473.8**	**-839.0**	**-872.1**	**-586.4**	**-420.1**	**-112.3**	**-324.7**	**-184.0**	**50.5**	**-1,030.2**	**-6,792.0**

***** Deficit/surplus for all stationary installations does not correspond with the sum of deficit/surplus for combustion of fuels and industrial installations. See note Table 2.12.

Table 2.14 – *Percentage of cumulative free allowances deficit/surplus by sector in the period 2008-2020 in the examined countries, the group of other countries, and all countries. Industrial sectors in decreasing order of total deficit/surplus.*

Activity	DE	PL	UK	IT	ES	FR	NL	CZ	SE	Other	All
Pig iron or steel	75.6%	57.3%	0.8%	56.2%	49.3%	14.1%	69.4%	40.6%	68.9%	23.0%	41.8%
Cement clinker	-3.7%	-5.1%	17.9%	33.2%	43.2%	14.3%	44.8%	1.8%	-8.1%	24.9%	18.9%
Bulk chemicals	14.6%	-0.6%	9.5%	21.1%	16.1%	42.1%	31.7%	-2.1%	177.9%	16.6%	16.9%
Paper or cardboard	21.1%	-15.0%	16.0%	-11.7%	-12.8%	64.9%	6.4%	-0.5%	333.5%	36.5%	20.2%
Ceramics	7.8%	7.4%	27.0%	10.6%	39.4%	31.9%	-0.3%	29.0%	8.8%	43.9%	25.6%
Lime, or calcination…	0.5%	-4.3%	6.1%	32.8%	5.7%	12.1%	2990%[a]	-8.6%	10.2%	20.4%	9.4%
Ferrous metals	-5.9%	47.7%	135.6%	15.6%	21.4%	2.0%		-14.7%	2.8%	-0.7%	21.8%
Pulp	25.0%		-22.1%	-23.7%	-4.7%	62.5%		13.5%	178.4%	27.0%	32.8%
Soda ash and sodium bic.	92.1%	138.6%	161.6%		-19.7%	-5.0%				57.7%	34.9%
Adipic acid	703.4%										703.4%
Coke	-45.4%	30.2%	26.9%		75.8%			65.0%		14.2%	5.1%
Other activity opted-in	-100.0%		-23.1%	39.3%		736.9%		164.2%	31.0%	62.1%	41.2%
Non-ferrous metals	-0.4%	-7.5%		-2.7%	-11.4%	-8.5%	235.2%		37.5%	25.3%	4.0%
Nitric acid	3.2%	16.3%			-18.8%	37.1%		-22.6%	98.4%	10.1%	5.1%
Carbon black	-3.7%	14.1%			23.3%	19.6%	-16.9%		12.1%	-2.8%	1.6%
Gypsum or plasterboard	6.4%	7.1%	1.3%	-12.9%	25.5%	2.6%	-44.9%		-55.5%	4.9%	1.6%
Glyoxal and glyox. acid	-25.3%										-25.3%
Capture of GHG			-100.0%							-21.4%	-21.8%
Mineral wool	-8.4%	7.3%	17.1%	70.4%	2.2%	-21.3%	-3.0%	-12.0%	-13.5%	-16.3%	-0.5%
Secondary aluminium	-11.1%		-23.9%	-7.9%	31.8%		-18.6%	-19.0%		-8.3%	-8.9%
Glass	-5.3%	-2.7%	-2.1%	-8.5%	3.7%	7.4%	-2.2%	13.1%	8.2%	0.7%	-0.6%
Metal ore roasting or sint.	106.8%	-18.9%		13.2%			-100.0%		-2.5%	-5.1%	-5.7%
Hydrogen and synth. gas	-7.5%		1.5%	-18.8%	-18.9%	-18.8%	0.3%			15.2%	-5.3%
Primary aluminium	-16.3%		-22.2%	674622%[a]	-6.1%	-6.1%	16.2%		-28.6%	-12.0%	-10.9%
Ammonia	-17.9%	-22.1%	1.8%		-25.6%	-8.2%	-3.0%			-16.2%	-13.1%
Refining of mineral oil	-9.4%	-0.3%	-4.7%	-23.4%	-3.7%	-6.3%	-7.5%	2.0%	3.9%	-9.8%	-9.6%
All industrial instal.	**16.6%**	**6.4%**	**11.3%**	**12.5%**	**19.7%**	**10.7%**	**17.6%**	**20.2%**	**43.6%**	**14.0%**	**14.8%**
Combustion of fuels	**-63.9%**	**-41.2%**	**-49.5%**	**-51.5%**	**-57.5%**	**-27.2%**	**-51.7%**	**-30.6%**	**-14.8%**	**-39.7%**	**-48.9%**
All stationary instal.[b]	**-43.8%**	**-32.9%**	**-36.0%**	**-27.1%**	**-25.3%**	**-8.3%**	**-29.3%**	**-20.6%**	**20.1%**	**-19.6%**	**-29.1%**

[a] The percentages are due to free allowances in the period 2008-2009 to sectors that have stopped the activity.

[b] See note Table 2.12.

Free allowances surplus enters in the carbon market to offset deficit, mainly by combustion of fuels installations. The balance between allowances demand and supply in the carbon market affects the carbon price, moreover the available allowances should balance the verified emissions in order to not have any surplus in the overall system. Such balance is the key driver of the ETS to reduce emissions.

A summary for the total allocated allowances, therefore also considering the allowances auctioned or sold, shows that in the period 2008-2020 there are countries with net deficit or net surplus and at overall level there is a slight deficit of allowances (-48.3 $MtCO_2eq$) compared to the cumulative verified emissions (Table 2.15). Considering the surrendering of units according to the compliance process the difference between the total allocated allowances and the surrendered units provides the deficit/surplus among countries. The cumulative deficit/surplus at overall level is substantially balanced with a slight deficit of allowances (-24.1 $MtCO_2eq$).

Table 2.15 – *Cumulative free allowances deficit/surplus, allowances auctioned or sold and total allowances deficit/surplus of allowances compared to verified emissions and surrendered units ($MtCO_2eq$) from 2008 to 2020.*

Countries	Free allowances deficit/surplus	Allowances auctioned or sold	Total allowances deficit/surplus compared to verified emissions	Total allowances deficit/surplus compared to surrendered units
Germany [a]	-2,473.8	1,462.1	-968.5	-970.1
Poland	-839.0	505.4	-333.7	-333.0
Italy	-872.1	769.6	-102.4	-97.0
United Kingdom	-586.4	599.1 [b]	12.7 [b]	13.0 [b]
Spain	-420.1	543.8	123.7	124.5
France	-112.3	339.6	227.3	228.8
Netherlands	-324.7	223.9	-100.8	-100.8
Czechia	-184.0	195.0	11.0	9.2
Sweden	50.5	55.9	106.4	106.3
Other countries	-1,030.2	1,706.3	676.0	694.9
All countries	**-6,792.0**	**6,700.5** [c]	**-48.3** [c]	**-24.1** [c]

[a] Germany cumulative total allowances is 43.2 $MtCO_2eq$ higher than the sum of auctioned or sold allowances and corrected free allowances. For all other countries there is no difference.
[b] UK allowances auctioned or sold in 2019 are not available. In 2018 and 2020 the allowances auctioned or sold respectively 101.1 and 111 $MtCO_2eq$.
[c] Figures for all countries consider also the NEC300 auctioned allowances.

The data show that at overall level the EU-ETS has a substantial balance between total allowances and verified emissions with a slight deficit of total allowances, although at sectoral level significant surplus of freely allocated allowances has been recorded for relevant industrial sectors. Reducing such surplus is a key factor to achieve the GHG emission reduction targets in the EU-ETS. The revision for phase 4 should consider the actual risk of carbon leakage without introducing market distortion with excessive sector surplus of free allowances.

2.3 ETS emissions from aviation

The aviation sector joined in the EU ETS on 1 January 2012. The sector is briefly summarized as the main goal of this report is focused on stationary installations.

In 2012 the emissions from the sector accounted for about 4% of total amount of ETS emissions. The aviation share of emissions, although quite variable, ranges from the highest 4.5% in 2019 to the lowest 1.8% in 2020. Just after the first year the sector showed a sharp fall of emissions, from 84.0 $MtCO_2$ to 53.5 $MtCO_2$ in 2013. Since the beginning of the 3rd phase the sector emissions increased up to 2019 (+27.5% compared to 2013). The sector has been heavily affected by lockdown measures to contain the

diffusion of SARS-CoV-2 pandemic in 2020 and emissions fell by 63.5% compared to the previous year (Figure 2.65).

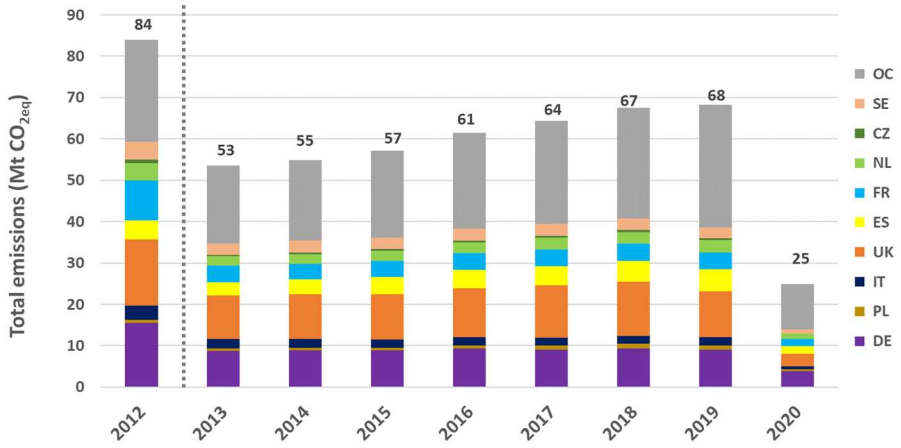


Figure 2.65 – *Trend of GHG emissions in the aviation sector.*

Figure 2.66 shows the number of operators for each year that, as the emissions, sharply decreased from 2012 to 2013. The number of operators decreased drastically in 2020.

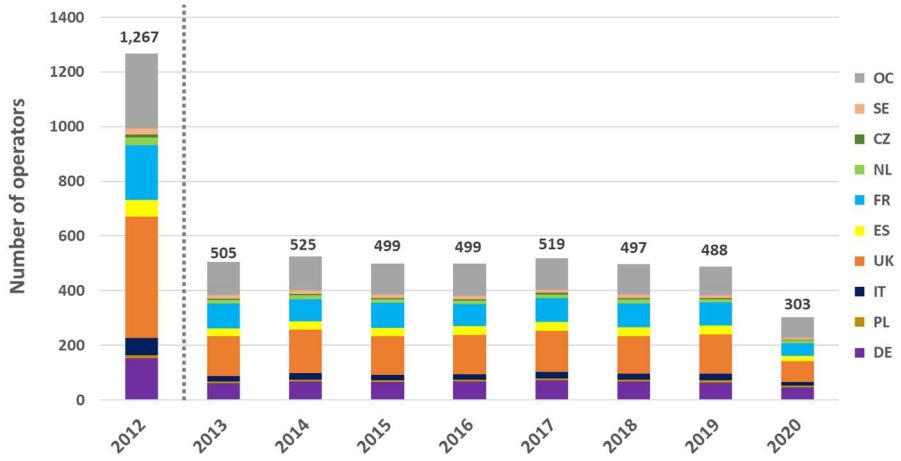


Figure 2.66 – *Trend of operator number in the aviation sector.*

The emissions share by country has changed relevantly from 2012 to 2020. The share of the biggest countries decreased from 70.7% to 55.8%. The highest share in 2012 was in UK (19.1%), Germany (18.5%), and France (11.6%). In 2020 only two countries increased their emission share: Poland from 0.8% to 1.7% and Spain from 5.3% to 7.2%.

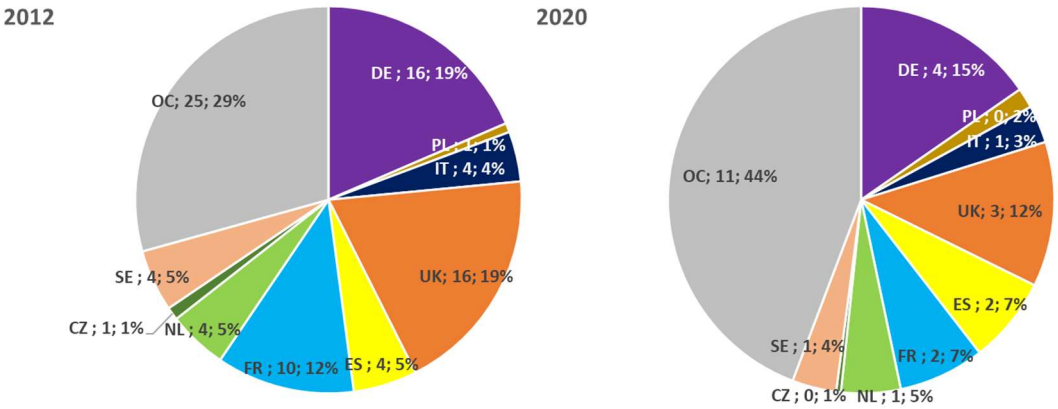


Figure 2.67 – *Share of emissions from aviation sector by countries.*

Figure 2.68 shows the ratio between allowances and verified emissions. In 2012 the availability of free allowances was more than double the verified emissions. Since 2013 the free allowances availability decreased steadily from 60.1% to 44.3% in 2019. In 2020 free allowances are 21.1% more than the verified emissions.

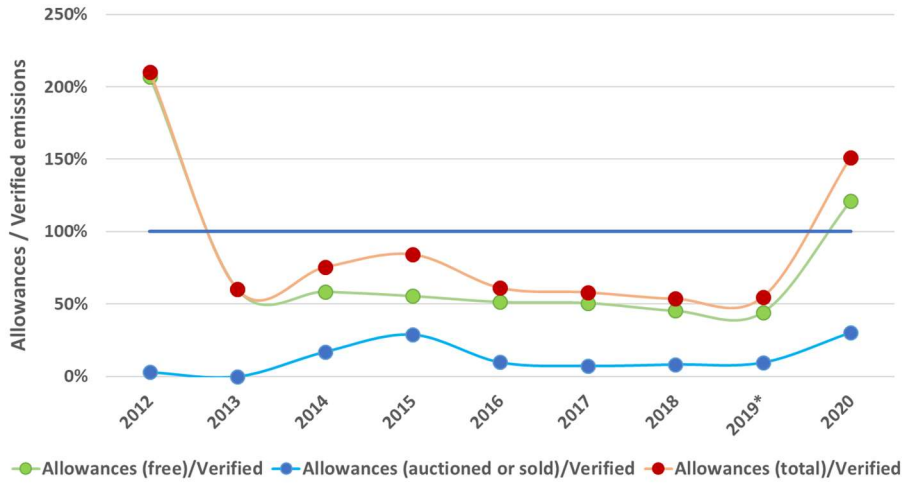


Figure 2.68 – *Percentage of allowances compared to verified emissions.*

Figure 2.69 shows the reduction of the free allowances share in total allowances after 2013 up to 2014 with a recovery in the next years up to 87.3% in 2017 and a decreasing trend up to 2020.

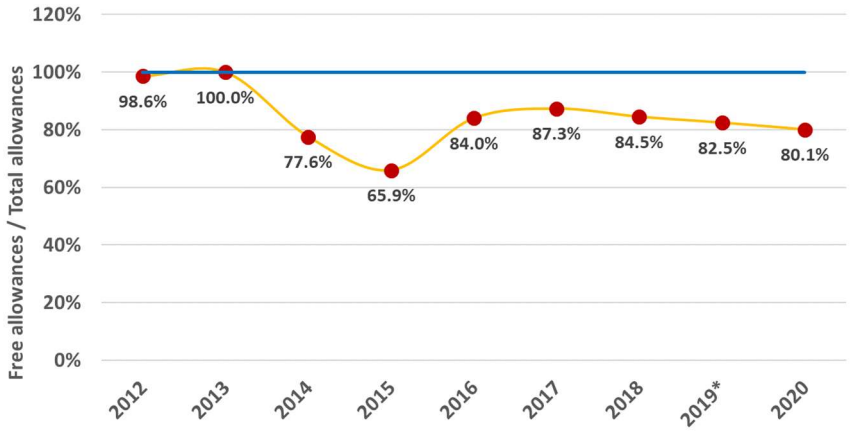


Figure 2.69 – *Percentage of free allocated allowances compared to total allowances from 2012 to 2020. * UK allowances auctioned or sold in 2019 are not available so for this year UK data are not considered.*

The ratio between cumulative allocated allowances (freely allocated and auctioned or sold) and cumulative verified emissions (Figure 2.70) shows the relevant surplus of free allowances in the biggest countries in 2012 which substantially decrease in the 3rd phase, except for Czechia.

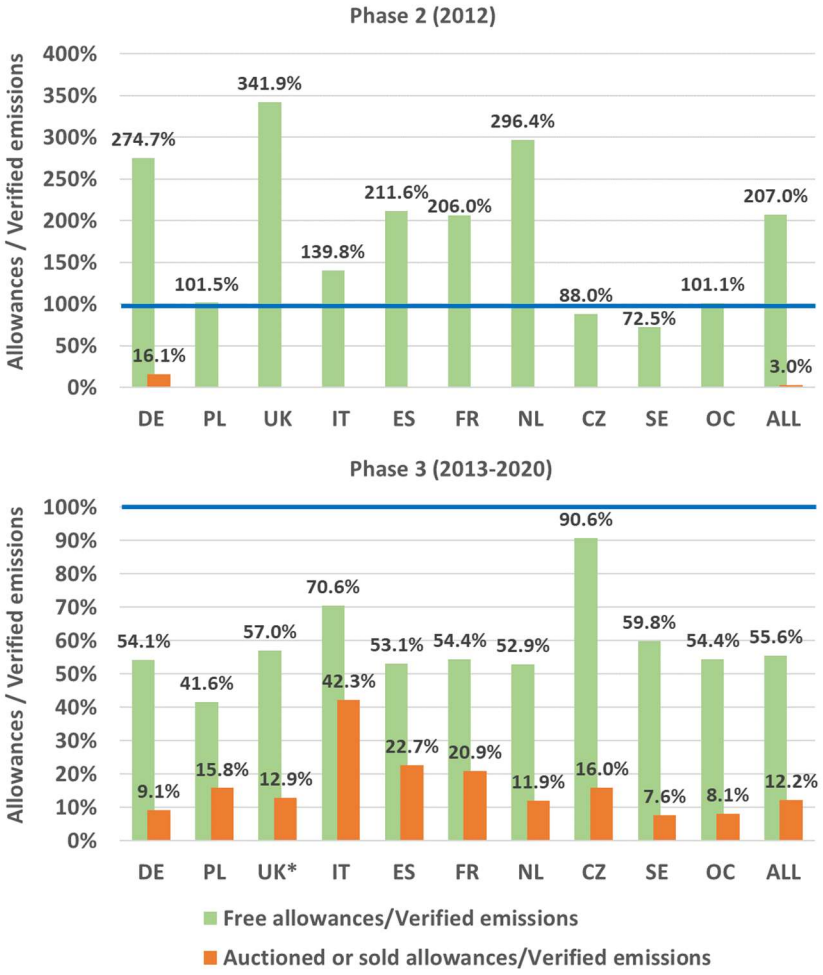


Figure 2.70 – *Percentage of cumulative allowances (freely allocated and auctioned or sold) compared to cumulative verified emissions in the three ETS phases. OC: other countries; All: all countries. * UK allowances auctioned or sold are not available in 2019; the data do not consider this year for UK.*

The cumulative ratio by country for all years (Figure 2.71) shows that the biggest countries have the higher percentage of free allowances compared to verified emissions, higher than the overall average. The only countries with surplus of free allowances are Cyprus and the United Kingdom.

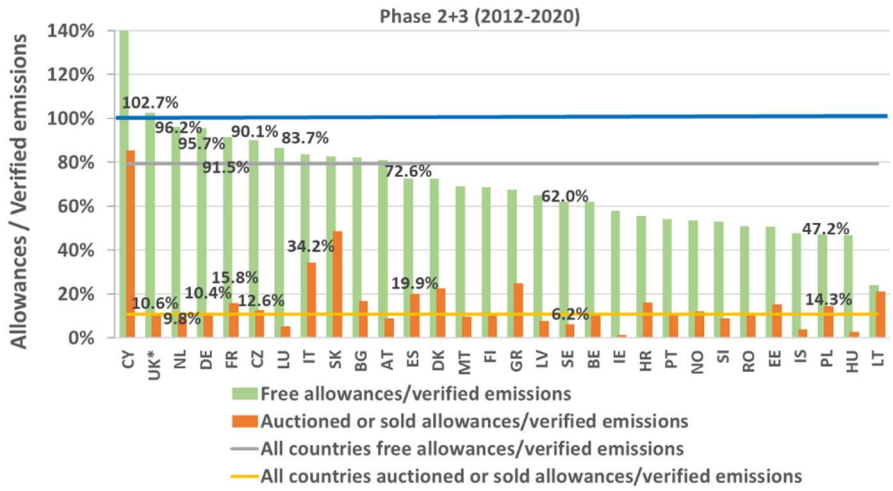


Figure 2.71 – *Percentage of cumulative allowances (freely allocated and auctioned or sold) compared to cumulative verified emissions in the ETS phases 2 and 3. Countries in descending order of the free allowances to verified emissions ratio. The labels for the examined countries are reported. * UK allowances auctioned or sold are not available in 2019; data do not consider this year for UK.*

CONCLUSIONS

EU ETS in Italy

The Italian installations in the EU ETS are about 1,000 for more than a third belonging to the power, paper or cardboard, and ceramic sectors. The industrial installations represent more than 85%. The ETS sectors have accounted for more than a third of national greenhouse gas emissions in recent years.

In 2020 power plants account for more than half of ETS emissions, followed by refining of mineral oil, cement clinker and bulk chemicals sectors. Such sectors account for more than 75% of ETS emissions in 2020. Overall, the Italian ETS emissions fell down by 49.1% in the period 2005-2020 considering the estimated emissions in 2005 to reflect the current ETS scope. Most of the emissions are due to a relatively small number of installations. In 2020, more than 75% of emissions are produced by 94 installations.

The average emissions per installation decreased from 2005 to 2020 from 239.9±886.4 kt CO_2eq to 129.4±414.9 kt CO_2eq. In the power sector the average emissions per installation fell by 50%, while in the industrial sectors the reduction was by 35.2%.

The ratio by sector between free allocated allowances and verified emissions shows that, despite measures to stabilise the carbon market, the reduction of activities has led to allowances surplus in some sector even in the 3rd phase. The main sectors with cumulated surplus for 2nd and 3rd phases are cement clinker (ratio 1.33), integrated cycle pig iron or steel (1.79), ceramics (1.13), production of lime or calcination of dolomite/magnesite (1.33), textiles (1.52).

Total energy consumption of the ETS amounted to 69.5 Mtoe in 2005, about 37% of the gross inland consumption. In 2020 the energy consumption fell to 44.5 Mtoe, about 31% of gross inland consumption. Both ETS energy consumption and gross inland consumption trends declined since 2005, although ETS share with higher speed. ETS energy consumption fell by 36% from 2005 to 2020, while greenhouse gas emissions fell by 44.2%. Emissions by fuel consumption account for more than 90% of total emissions and fell by 42.9% from 2005 to 2020. The trends of emissions by fuel and activity sector provide an insight concerning the potential to reach the emissions reduction in ETS sectors by 2030. According to the last Italian emission projections submitted by ISPRA to the European Commission in March 2021, prepared before the 'fit for 55' package proposals but reflecting the consequence of the Covid-19 pandemic, the ETS emissions projected in 2030 will be 123.0 $MtCO_2$ for the scenario with existing measures (WEM; -50.3% compared to 2005) and 95.7 $MtCO_2$ for the scenario with additional measures (WAM; -61.4% compared to 2005). The current ETS revision should result in an overall emission reduction of sectors under the EU ETS of 61% by 2030 compared to 2005. Appling such reduction to the current Italian ETS sectors the emissions from stationary installations in 2030 should be about 97 $MtCO_2$, about 26 $MtCO_2$ less than WEM scenario but about 1 $MtCO_2$ above the WAM scenario. Such figures show clearly that Italy needs additional that Italy needs additional measures set up in the National Energy and Climate Plan measures to reach the new ETS target and that a crucial role will be played by power sector with the coal phase out by 2025 and the increase of renewable electricity up to 55% by 2030 from current 40%.

The emission factors by sector for fuel consumption, ratio of CO_2 emissions to energy content, decreased by 10.8% in the period 2005-2020 mainly driven by power plants where the share of natural gas increased more than in other sectors. In such plants the share of energy from solid fossil fuels and no gaseous petroleum products fell down sharply, from 42.1% to 19.9% from 2005 to 2020, while the share of natural gas increased from 46.6% to 63.3%. In the industrial installations, the share of natural gas energy consumption increased from 32.8% to 50.8% in the period 2005-2020.

With regard to the distribution of ETS emissions on Italian territory the top three regions are Lombardy, Apulia, and Sicily. The emissive intensity per plant shows a sharp decrease throughout the territory. The southern and island regions have the highest emissive intensities both for power plants and industrial installations, with values ranging from 1.8 to 3.5 times the national average in 2020. ETS

emissions in 2020 in the North West and North East (54.2 $MtCO_2eq$) are just below those recorded in the South and Islands (55.9 $MtCO_2eq$) compared to 3.3 times more installations.

EU ETS in the biggest European countries

Analysis of European data shows that the top eight ETS emitting countries are responsible for more than 75% of EU ETS emissions by stationary installations in 2020 (76.7% with Sweden). Germany, Poland, Italy and the United Kingdom account for more than 50%. Germany alone accounts for almost a quarter. Industrial installations in the biggest countries account for 71.2% of ETS industrial emissions.

Emissions from all stationary installations in 2020 amount to 1,555.1 $MtCO_2eq$. (-42.8% compared to 2005 considering the estimated emissions in 2005 to reflect current ETS scope). Combustion of fuels installations account for the majority share with 60.6% of ETS emissions. The next biggest sectors are cement clinker (8.4%), refining of mineral oil (8.4%), and pig iron or steel (7.8%).

Among the biggest countries the UK, Spain and Italy have the highest average annual reduction rates, from 4.4% to 6.2%. France and Germany recorded annual reduction rates of 4.1% and 3.1%, respectively, while at the lower end the Netherlands recorded the lowest annual reduction rate of 1.4%.

The observed emissions reduction is mainly due to combustion of fuels plants which reduced emissions by more than 43% from 2005 to 2020. Emissions by industrial installations do not show statistically significant negative trend, except from 2009 to 2012 when the effect of the economic and financial crisis contracted production activities and emissions from industrial sectors in many countries. After 2012 emissions from industrial sectors exceeded 2005 levels, also as the result of ETS scope extension in phase 3 and the entry of new plants. From 2013 to 2020, emissions from industrial installations decreased by 9.3%, although a not statistically significant trend.

The average emissive intensity per plant recorded in combustion of fuels plants has been higher than in industrial sectors up to 2018. The industrial installations, with the exception of refining of oil, pig iron or steel, cement clinker and a few other sectors, are characterized by smaller emissions size. Trends in emissive intensity per plant in industrial sectors and combustion of fuels plants converge to comparable values in 2019 and in 2020 the emissive intensity per plant in industrial sectors is higher than combustion of fuels.

The ratio by activity sector of cumulative freely allocated allowances to verified emissions for all the stationary installations shows that some sector received more free allowances than the verified emissions even in the 3rd phase. Pig iron or steel sector, bulk chemicals, and cement clinker sectors recorded surpluses of free allowances compared to the verified emissions since 2013 of 28%, 12%, and 7% respectively. Considering also the allowance banking from the 2nd phase the surpluses rise to 42% for pig iron or steel, 17% for bulk chemicals, and 19% for cement clinker. Several countries had surplus of free allowances for such sectors. As stated in the recent Report of the European Court of Auditors (2020) the surplus is due to the poor quality of data used to establish benchmarks and the limited alignment with the data of the specific production activities. The current proposal of revision for the 4th ETS phase deeply change the benchmarking methods to better align the free allocation with actual production levels.

The ratio at country level of free allowances to verified emissions cumulated from 2008 to 2020 shows that countries as Romania, Lithuania, Latvia, Sweden and Liechtenstein have relevant surpluses of free allowances. Looking only at the industrial sectors, it emerges that, among the examined countries, Sweden, Czechia, Spain and Germany have the highest surpluses, respectively 43.6%, 20.2%, 19.7%, and 16.6%. The Italian surplus is 12.5%. Overall, the surplus in the industrial installations is 14.8%. The combustion plants, where the auctioned or sold allowances are predominant, have deficits of free allowances that range from 14.8% in Sweden to 63.9% in Germany.

In summary, all EU-ETS stationary installations show a substantial balance between total allowances available (freely allocated and auctioned or sold) and verified emissions with a slight deficit. However, there are a number of cases of surplus at sectoral level. Therefore, in accordance with the recommendations made by the European Court of Auditors, the benchmark update with annual

adjustment to align the level of free allocation with actual production levels looks a good approach to correct such distortions.

With regard to the emissions trend, Italian data show that a structural driver for downward trend is the increasing share of natural gas and decreasing share of solid fossil fuels and petroleum products in the energy mix, especially in power sector. In 2020 emissions from combustion of fuels plants at European level account for more than 60% of all EU ETS stationary installations. Germany and Poland account together for 36.3% of total ETS emissions and 41.7% of emissions from combustion of fuels plants. In Germany and Poland, the share of solid fossil fuel energy, mainly lignite, used in the power sector was respectively 53.5% (without nuclear heat) and 83% in 2019, compared to 10.8% in Italy (ISPRA, 2021[d]). In addition, the average annual reduction rate of energy from solid fuels in the thermoelectric sector in the period 2005-2019 was -3.7% in Germany, -1.7% in Poland and -6.1% in Italy. These data highlight the potentials for reducing emissions from combustion of fuels plants in countries with higher emissions and higher levels of solid fossil fuel in their energy mix. Given the importance of such plants in the EU ETS and the relevance of the emissions from countries as Germany and Poland, the reduction potential of these countries is a driver for the reduction potential of the whole system.

The aviation sector joined in the EU ETS on 1 January 2012. In 2020 the emissions from the sector accounted for about 1.8% of total amount of ETS emissions. Since the beginning of the 3rd phase the emissions increased up to 2019 (27.5% compared to 2013). The sector has been heavily affected by lockdown measures to contain the diffusion of SARS-CoV-2 pandemic in 2020 and emissions fell by 63.5% compared to the previous year. The ratio between cumulative allocated freely allocated allowances and cumulative verified emissions since 2012 shows that the only countries with surplus of free allowances in the sector are Cyprus and the United Kingdom.

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ANNEX – CORRESPONDENCE AMONG ITALIAN AND EEA DATABASE MAIN ACTIVITY SECTORS (2020)

The sectoral classification used for the Italian data analysis (chapter 1) does not coincide with that in the EEA database, so it is not possible to have a perfect match between main activity sectors for the two data sets. However, it is possible to identify correspondences according to the main activity sectors assigned at installations level in the EUTL available in the following URL (last access 1st October, 2021): https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/verified_emissions_2020.xlsx

The following table shows the number of installations and the emissions in 2020 according to the two classifications.

Table A1 – *Number of plants and emissions for 2020 sectors according to EEA database and national classification.*

EEA sector	IT sector	N° of plants	Emissions $ktCO_2eq$ (2020)
Combustion of fuels	Power plants	126	63,265.1
	Bulk chemicals	55	3,454.4
	Ceramics	5	81.9
	District heating	54	2,827.0
	Extraction	11	1,410.8
	Food & beverage	104	1,700.5
	LNG regasification	3	229.9
	Mechanics	43	784.9
	NG pipeline compression	21	548.5
	Other activity sectors	39	474.6
	Pig iron or steel (el.)	3	52.1
	Textile	18	140.5
	Waste incineration	9	146.7
Combustion of fuels	**Subtotal**	**491**	**75,116.9**
Refining of mineral oil	Power plants	1	164.2
	Refining of mineral oil	14	15,221.9
Refining of mineral oil	**Subtotal**	**15**	**15,386.1**
Production of cement clinker	Cement clinker	29	11,063.1
	Lime, or calcination…	3	138.1
Production of cement clinker	**Subtotal**	**32**	**11,201.2**
Production of pig iron or steel	Pig iron or steel (el.)	34	2,854.0
	Pig iron or steel (IC)	2	4,871.9
Production of pig iron or steel	**Subtotal**	**36**	**7,725.9**
Production of paper or cardboard	Power plants	1	211.6
	Paper or cardboard	104	3,303.2
	Subtotal	**105**	**3,514.8**
Manufacture of glass	**Glass**	**50**	**2,673.6**
Manufacture of ceramics	**Ceramics**	**107**	**2,506.7**
Production of bulk chemicals	**Bulk chemicals**	**21**	**2,367.3**
Production of lime, or calcination of dolomite/magnesite	Ceramics	1	136.7
	Lime, or calcination…	20	1,560.1
Production of lime, or calcination of dolomite/magnesite	**Subtotal**	**21**	**1,696.8**
Production or processing of ferrous metals	Mechanics	2	52.1
	Pig iron or steel (el.)	40	984.2
	Pig iron or steel (IC)	1	160.2
Production or processing of ferrous metals	**Subtotal**	**43**	**1,196.4**
Other activity opted-in pursuant to Article 24 of Dir. 2003/87/EC	Power plants	2	165.2
	Bulk chemicals	4	401.6
	Ceramics	2	54.8
	District heating	1	3.7
	Food & beverage	1	54.9
	Mechanics	1	4.8
Other activity opted-in pursuant to Article 24 of Dir. 2003/87/EC	**Subtotal**	**11**	**684.9**

EEA sector	IT sector	N° of plants	Emissions $ktCO_2eq$ (2020)
Production of hydrogen and synthesis gas	**Bulk chemicals**	**3**	**620.9**
Production of pulp	**Paper or cardboard**	**19**	**574.0**
Production or processing of non-ferrous metals	Non-ferrous metals	9	503.4
	Pig iron or steel (el.)	1	19.7
Production or processing of non-ferrous metals	**Subtotal**	**10**	**523.1**
Production of secondary aluminium	**Non-ferrous metals**	**5**	**122.2**
Production or processing of gypsum or plasterboard	Ceramics	1	23.5
	Other activity sectors	3	70.3
Production or processing of gypsum or plasterboard	**Subtotal**	**4**	**93.8**
Metal ore roasting or sintering	**Bulk chemicals**	**1**	**28.5**
Total		**974**	**126,033.0**

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