



# **Sectoral case study – Soda ash**

## **Climate for Sustainable Growth**

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The views expressed are attributable only to the authors in a personal capacity and not to any institution with which they are associated, or the funders and supporters of this project.

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This case study is part of the CEPS project 'Climate for Sustainable Growth', whose main objective is to analyse the impacts of climate change mitigation measures on the three pillars of sustainable development: the economic, environmental and social dimensions.

It does so by looking at the positive as well as negative, both intended and unintended, impacts of climate change mitigation policies and projects. While this case study fully recognizes that policies have both positive and negative impacts, the focus of is on (potential) negative impacts of climate change mitigation policies.

The structure of this case study comprises of four sections:

- (1) Sector characteristics,
- (2) Climate-related policies,
- (3) Environmental, social and economic impacts of climate mitigation policies,
- (4) Measures to mitigate impacts of mitigation policies,

This case study, and the methodology it follows, are not intended to analyse the merit of the policies and measures that are being implemented, or their effectiveness and efficiency, but will focus on their socio-economic-environmental impacts, and measures to alleviate these impacts in the period of transition.

It is important to note that lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action. This case study and the overall project's focus should be seen in this light.

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## Executive Summary

This case study is part of the project entitled “Climate for Sustainable Growth” and focuses on the energy intensive sector of soda ash. Soda ash is a chemical product used in the production of glass, detergents as well as in other chemicals.

This study examines whether climate change policies that impact the soda ash sector are being put in place in a sustainable way, by identifying their impacts on the three dimensions of sustainable development: 1) economic 2) social and 3) environmental. This understanding is critical for the speed with which mitigation measures can be implemented, for the buy-in they receive from stakeholders and for ensuring that they meet the conditions for sustainable development, which implies there is progress on all three dimensions in a harmonious way.

This study looks at the positive as well as negative, both intended and unintended, impacts of climate change mitigation policies and projects. Given the broad scope of the topic, this study focusses on climate change mitigation policies in the EU, and more specifically the EU Emissions Trading Scheme (EU ETS).

After identifying the positive and negative impacts of the EU ETS, domestically and internationally, the case study examines the measures put in place to mitigate the (potential) unintended negative impacts of climate change mitigation policies.

It finds that the EU ETS has both positive and negative, both intended and unintended, impacts on the three dimensions of sustainable development. It also finds that the impacts at the present time are limited and constitute only one of many factors affecting the competitiveness of the European soda ash industry. It concludes that there are international impacts that could transmit the cost emerging from the carbon price in the EU to other jurisdictions, including developing countries.

From the economic perspective, as a result of a carbon price, the EU ETS creates three types of costs for the soda ash sector:

- A. Direct cost: the cost of buying EU allowances (EUAs) to comply with the EU ETS.
- B. Indirect cost: the EU ETS cost passed through to the soda ash sector in input prices.
- C. Administrative costs: one-off costs for the start-up of the process, and recurring Monitoring, Reporting and Verification (MRV) costs.

Direct and indirect costs are assessed together in this study, as soda ash plants are often integrated with heat and/or power producing installations. These costs are deemed intended as they aim to drive low GHG innovation. Administrative costs are considered minor and necessary, to some extent, for the functioning of the EU ETS. The administrative costs are estimated at €0.1 per tonne of soda ash.

The total EU ETS cost for a plant depends on its emission intensity of production and the level of EUA prices. Low emission-intensive plants currently face EU ETS costs of 0.2% of total production costs, high emission-intensive plants face EU ETS costs of 3% of total production cost (EUA prices of €8).

Note that these EU ETS costs are intended impacts of the EU’s flagship climate change policy. By internalizing the costs of GHG emissions, emission reductions are incentivized and revenue from auctioned allowances is mobilized. Though this is currently not the case, these revenues could be

recycled in order to mitigate the unintended impacts of the EU ETS. These unintended impacts can either be found within the EU, or outside of the EU.

The intended ETS cost have potential unintended consequences. Production cost increases can result in a weakened competitive position, which can impact trade flows, investment, production levels and employment in the EU and lead potentially to no net emission savings. These impacts are unintended impacts of the EU ETS.

The unintended impacts in the EU mostly result from the inability of installations under the EU ETS to fully pass on costs to downstream users and consumers. The production cost increases because of direct, indirect and administrative EU ETS costs could lead to installations losing competitive position vis-à-vis installations in jurisdictions with less, or no, climate change related constraints. This may result in unintended economic impacts (such as reductions in trade, production or investment), unintended social impacts (such as loss of employment opportunities) and unintended climate policy impacts (such as carbon leakage). Note that carbon leakage will not result in net-GHG emission reductions if production or investment is displaced from EU installations to plants based on the Solvay or Hou processes outside the EU.

There are also potential unintended impacts, difficult to quantify, for soda ash users in third countries: EU ETS costs could be passed through to them through increases in the price of soda ash internationally. This has the potential to impact the cost of glass, and some consumer products, in developing countries.

The unintended impacts of the EU ETS cannot be segregated in current trade, investment and production trends, as macroeconomic events, such as the economic and financial crises and energy prices, are deemed to have had a far greater impact.

However, the costs that emerge from the EU ETS have the potential to become substantial for soda ash producers, and may also emerge in the chain that includes users of soda ash in jurisdictions outside the EU, including developing countries. Three main factors will determine the EU ETS costs for the soda ash industry in the future: 1) the choice of fuel to generate heat 2) the evolution of the price of EUAs and 3) the continued reduction in freely allocated EUAs, which is the most important flanking measure to accompany carbon pricing.

On the positive side, the EU ETS encourages continued low-GHG innovation, which could be a boon to the EU soda ash sector if carbon pricing policies, under similar levels of effort, continue to spread globally.

Secondly, the unintended social impacts of the EU ETS on the soda ash sector have, so far, been limited. Emission reductions would improve local air quality and therefore have positive health benefits. However, significant production costs increases in the future could lead to unintended plant closures. A number of soda ash plants in the EU have closed down in the past decade, but energy prices are deemed a far greater factor in these closures than EU ETS costs.

Thirdly, the EU ETS has had positive environmental impacts by reducing the emissions of GHGs from power and industrial sectors. However, the lion's share of emissions reductions in these sectors since the inception of the EU ETS in 2015 is deemed attributable to the overlap with other policies such as renewables, as well as to the economic and financial crises.

The main unintended negative environmental impact is also an economic impact: the risk of carbon leakage. Climate change mitigation policies could cause the displacement of emitting activities to countries with no or less stringent climate change policies. If the emissions of those activities increase because of this displacement (for example due to the use of less emission-efficient technologies), then carbon leakage has taken place. There is currently no proof that production of soda ash has moved from the EU to other jurisdictions due to climate change mitigation policies.

Free allocation has been the main flanking measure put in place by the EU for the industrial sectors that are deemed at risk of carbon leakage. Such sectors receive free allowances up to the product benchmark, as defined by the least emission-intensive plants in that sector. Free allowances reduce the direct costs for industries, limiting the risk of unintended impacts materializing.

By giving free allowances, the direct cost of the EU ETS is reduced by more than 60% for high emission intensive soda ash plants. However, the amount of free allocation is set to diminish yearly, with free allocation 18.5 percentage points lower in 2020 than the benchmark. This could decrease the effectiveness of free allocation as a measure to mitigate negative impacts.

While the domestic social impacts of the EU ETS can be addressed through safety nets and flanking measures (such as retraining schemes) that exist in the EU member states, there is a lack of recognition and management of potential international impacts. The international impacts of the EU ETS are currently not the focus of policy makers, and are therefore not identified or measured in a systematic manner. Ultimately it is impossible to mitigate the negative impacts of climate-related policies if those impacts are not known.

This case study finds that the EU ETS currently has minor impacts, but that these could increase in the near future. These impacts are not only on emissions (their intended target area), but also in other facets of public policy – economic, social and environmental.

Some of these impacts are also international and reach beyond the jurisdiction implementing them. While these international impacts are difficult to quantify, given the level of EU allowance prices, it is unlikely that they have had a significant impact at this stage. It is important to note that they are not well understood, and therefore not managed.

Beyond the lessons learned specific to the soda ash case, the analysis here supports the notion that any climate change policies should be carefully assessed for their broader sustainable development impacts, domestically and internationally, both in their initial elaboration, as well as on an on-going basis.

However, it must be emphasized that this discussion must not be in any way be interpreted or construed as encouraging lack of mitigation action. On the contrary, it must be seen as providing a way forward that will ensure that action can be undertaken with full support by all stakeholders, domestic and international.

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# Sectoral case study –Soda ash

## Climate for Sustainable Growth

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### **1. Sector characteristics**

In order to discuss climate change mitigation policies and their impacts on the soda ash sector, it is necessary to briefly introduce the sector. This project focuses on climate change mitigation policies and the mitigation or management of expected and unexpected negative impacts resulting from those policies. This chapter characterises the sector according to the following seven factors:

- Historical context
- Downstream sectors
- Production processes
- Soda ash globally
- Soda ash in the EU
- Production costs
- Main climate impacts of the sector

#### **1.1 Historical context**

The use of soda ash – the trade name for sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) – dates back to ancient Egypt. Primarily used as a soap (hence the ‘soda’ in the name), it was produced until the 19th century by burning specific land and water vegetation (hence the ‘ash’). Production processes have, however, changed dramatically since then. In the second half of the 19<sup>th</sup> century the Solvay process was developed and became widely adopted. Production of soda ash from trona (a natural mineral) has been developing since the Second World War (Thieme, 2012).

#### **1.2 Downstream sectors**

Soda ash is used in a wide variety of applications and industries. The major consumers of soda ash are the glass, detergents and chemicals sectors. In the glass sector it is used for the production of flat glass and container glass, where it lowers the melting temperature of the batch, thereby reducing energy consumption by 5-10%, while also decreasing  $\text{NO}_x$  emissions (Grahl, 2002). Soda ash makes up around 20% of the volume of glass products (Ecofys, 2009a), and accounts for approximately 13% of flat glass production costs (Pilkington, 2010).

In the detergents sector, it is used for the production of washing powders, soaps and scouring powders. Additionally it is used as a water softener and to remove grease and alcohol stains. In the chemicals sector its main use is as a raw material in the production of sodium-based chemicals such as sodium bicarbonate, also known as baking soda (ESAPA, 2015). Figure 1 shows an overview of the

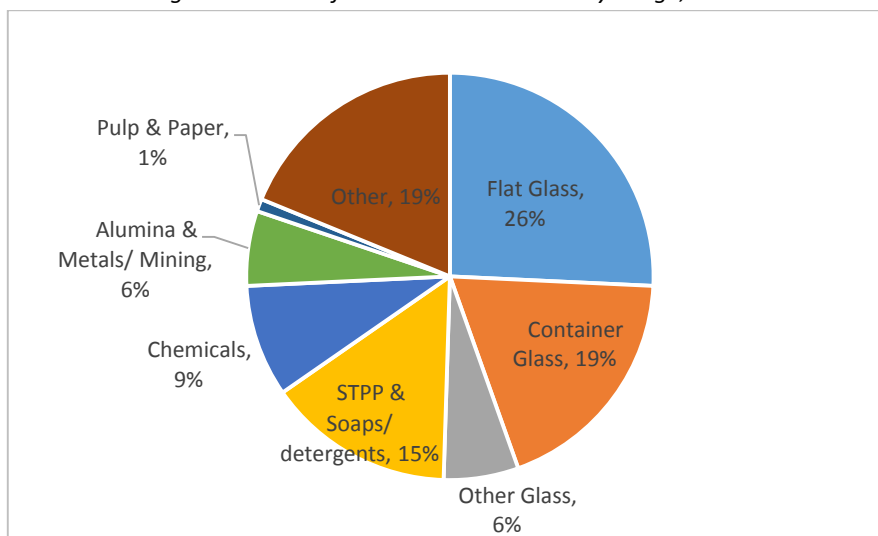
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\* Andrei Marcu is Head of Carbon Market Forum at CEPS. Wijnand Stoefs is Research Assistant at CEPS Carbon Market Forum, David Belis is Research Assistant at CEPS Carbon Market Forum and Katja Tuokko is Research Assistant at CEPS Carbon Market Forum. The authors of this case study would like to gratefully acknowledge the assistance and comments provided by Christina Hood. The authors are also grateful to IHS Chemicals for their cooperation and data.



global demand for soda ash per sector. The glass sector alone accounts for just over 50% of soda ash demand globally.

*Figure 1. Share of downstream demand by usage, 2015*



Source: IHS (2015).

### **1.3 Production processes**

Three dominant soda ash production processes are used worldwide; the Solvay process, the Hou process and trona-based process. Together they account for approximately 93% of all soda ash production capacity worldwide. The remaining 7% includes, among others, production from alkaline lakes (in Botswana, Kenya and California) and the Akzo dry lime process, which is similar to the Solvay process but only used in a very small number of plants (IHS, 2015).

#### **1.3.1 Solvay process**

This is globally the most widely used production process (45% of global producing capacity). It does not use trona as an input, but instead uses cheap and widely available salt brine (both from inland and sea-based sources) and limestone. This chemical process recycles ammonia, and only has calcium chloride as a major waste product (CEFIC, 2004).

The Solvay process is mainly used in large (typical production capacity of around 600,000 tonnes annually) plants in the EU and China. Its main climate change impacts result from the need for heat in the production process. Heat is generated by burning coal, gas or a combination. Between 8.9 and 12.35 gigajoules (GJ) of energy are necessary per tonne of soda ash (IHS, 2015; Sevas, 2007; ANSAC, 2010).

#### **1.3.2 Hou process**

The Hou process is very similar to the Solvay process and is mostly used in smaller coal-fired plants in China, which plants have a typical annual production capacity of 210,000 tonnes. It represents 25% of global production capacity. The Hou process does not produce calcium chloride as a by-product, but rather ammonium chloride (a fertilizer). However, there is currently a global overcapacity of ammonium chloride production (IHS, 2015).

The Hou process is more energy-intensive than the Solvay process, and uses approximately 14.25 GJ of energy per tonne of soda ash (ANSAC, 2010).

### 1.3.3 Trona process

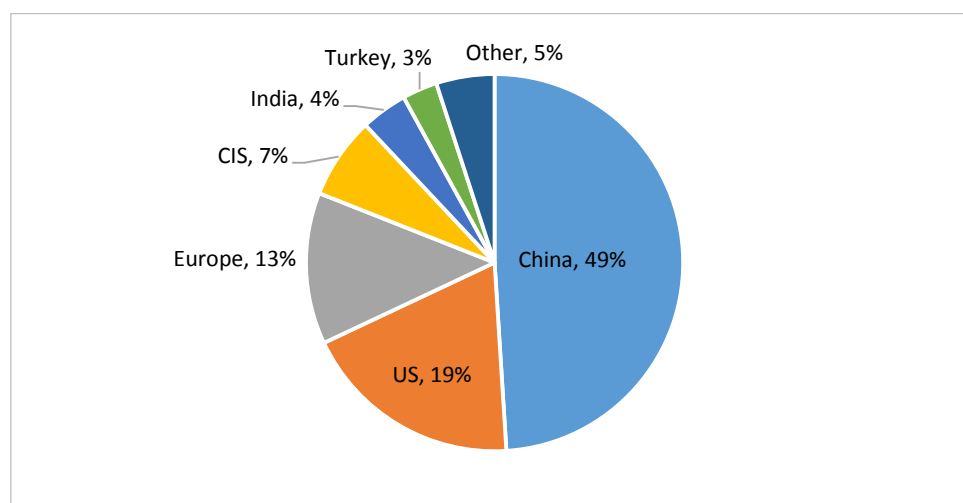
Soda ash produced with the trona process is also known as natural soda ash, as trona is a natural deposit. Trona plants often use a combination of gas and coal, and are by far the largest soda ash plants with a typical annual production capacity of 2.5 million tonnes. (IHS, 2015).

The trona process is far less energy-intensive (approximately 5.6 to 7 GJ per tonne of soda ash) and emits less GHGs, but is restricted due to the limited number of trona deposits worldwide and the purity of the available deposits. It represents 23% of global production capacity. In the US nearly all soda ash is trona-based. The world's largest trona deposit can be found in the Green River Basin, Wyoming (Thieme, 2012; CEFIC, 2004; USGS, 2015; IHS, 2015; ANSAC, 2010).

### 1.4 Overview of the global market

There are three major soda ash-producing regions: China, the US and the EU (see Figure 2). Global capacity is around 69.5 million tonnes per year. Currently there is a glut in the market: the utilisation of global capacity has dropped from approximately 90% in 2007 to just over 80% in 2013. Plants have been left idle in both China (operating in 2013 at approximately 80% of capacity) and the EU (2013 operating rate in 2013 at approximately 75% of capacity) (IHS, 2015).

Figure 2. Share of global production capacity by region, 2015

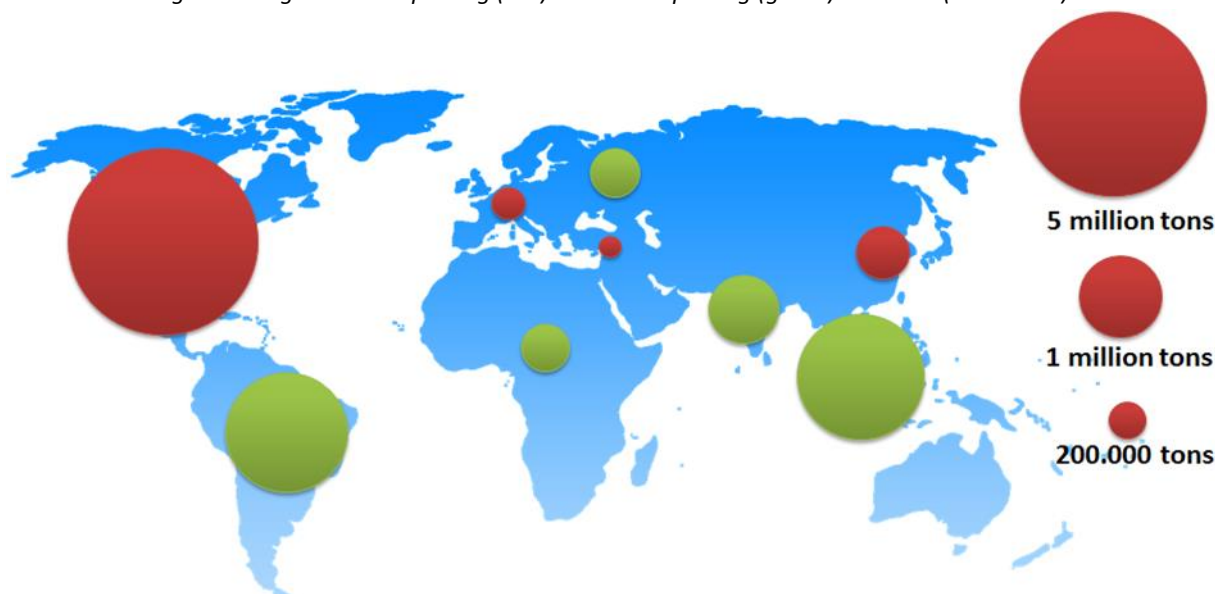


Source: IHS, 2015.

Soda ash is an internationally-traded commodity, with prices set mainly by the purity (or density) of the product.

There are three main exporting regions: the US, EU and China. The latter two mostly produce to cover internal demand, and export approximately the same amount. The vast majority of international demand, however, is met by cheaper US trona-based soda ash. South-East Asia, South-Asia and Latin-America are the main importing regions. Africa and Russia are also net-importers of soda ash as can be seen in Figure 3. The relative production costs are further assessed in this case study.

Figure 3. Regions net-exporting (red) and net-importing (green) soda ash (2013 data)



Source: IHS, 2015

Internationally soda ash is transported by sea and in bulk, and the transportation costs from the main exporting regions (US, EU, China) to the main importing regions (Latin America, India, South-East Asia, Africa) are comparable. For example shipping soda ash to India costs between \$35 and \$45 per tonne from either the US, the EU or China (IHS, 2015).

Overland transportation costs are significant. US production is mostly in Wyoming, from where soda ash is transported by train to ports. High US rail costs reduce the cost gap between the US and the rest of the world. This mitigates somewhat the cost advantages of trona-based soda ash over inland Chinese and EU producers.

The soda ash sector is dominated by a small group of companies; 10 companies represent approximately 45% of global capacity. The three largest companies are Solvay (22% of global capacity - with operations in the EU and the US), Tata (12% of global capacity - operations in India, the EU and Kenya) and Tronox (9% of global production capacity - operations in the US). The remaining 55% of global capacity comes from over 100 smaller firms, mostly based in China (IHS, 2015).

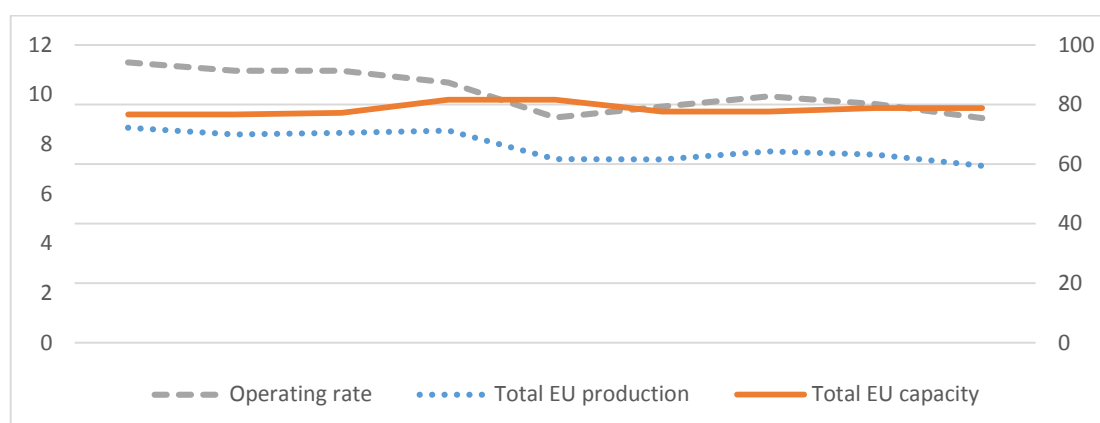
### 1.5 The EU soda ash sector

The soda ash sector in the EU employs approximately 22,500 people and generates sales of around €1 billion annually. More than 99% of EU soda ash is produced using the Solvay process. Four companies have dedicated soda ash plants, operating 12 plants Solvay process plants in the EU, down from 15 plants in 2007. Soda ash is a by-product for the fifth company. The EU has a total production capacity of nearly 9.5 million tonnes annually.

The largest company – Solvay – accounts for over 60% of EU soda ash production capacity. The second-largest producer – CIECH – accounts for approximately 25% of the EU's capacity (IHS, 2015).

However, as operating rates in the EU have declined (see Figure 4), production has decreased from 8.7 million tonnes in 2005 to 7.4 million tonnes in 2013.

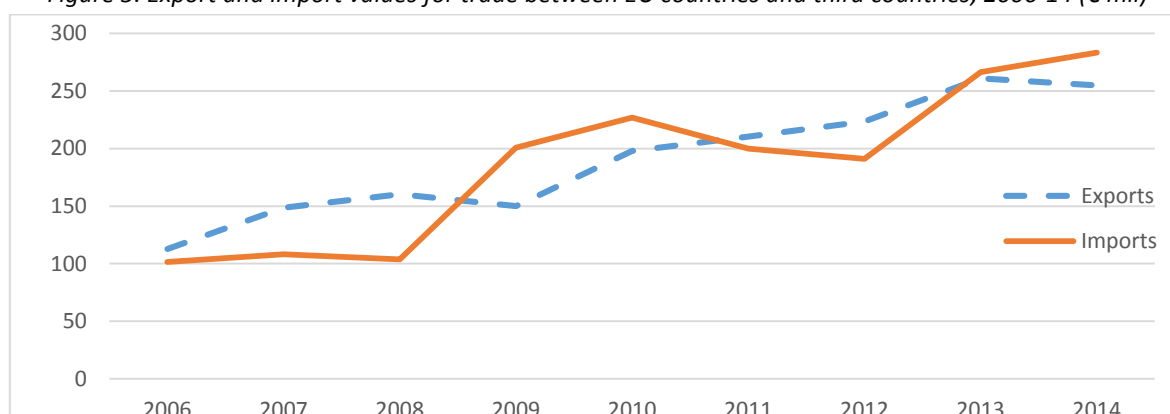
Figure 4. EU production, capacity (in million tonnes) and operating rates (right-hand side), 2005-13



Source: IHS, 2015.

Over the period 2007-13, imports have increased from 1.5 million tonnes in 2005 to 2.2 million tonnes in 2013. In 2013 the EU was still a net exporter of 150,000 tonnes of soda ash (2.33 million tonnes were exported and 2.17 million tonnes were imported). However, when we look at EU level trade data in terms of value (and not quantity), it becomes clear that there are large fluctuations in the soda ash trade balance from year to year.

Figure 5. Export and import values for trade between EU countries and third countries, 2006-14 (€ mil)



Source: Eurostat, 2015.

Imports from the US into the EU have remained stable between 2007 and 2013, while Turkish imports have risen steadily from less than 250,000 tonnes in 2007 to more than 800,000 tonnes in 2014. This situation is set to continue as investments in extra (trona-based) capacity have been announced in Turkey (IHS, 2015). Turkey's annual production capacity is expected to more than double over the next three years, from 2.9 million tonnes in 2015 to nearly 6 million tonnes by 2018.

The EU is currently the only region which has major climate change policies in place for the soda ash sector. This is set to change when the Chinese national emissions trading scheme (ETS) is launched; it is expected to start in 2017 (Carbon Pulse, 2015a). Chemicals is one of six sectors that will be covered by the national ETS, and larger soda-ash plants are likely to reach the threshold for coverage: installations emitting more than 26,000 tonnes of CO<sub>2</sub>e<sup>1</sup> are to be covered by the Chinese ETS (ICAP, 2015b).

<sup>1</sup> Since the majority of gases by the EU emissions trading scheme consist of carbon dioxide, all other gases are converted into CO<sub>2</sub> equivalent units, according to their warming potential, known as CO<sub>2</sub>e.

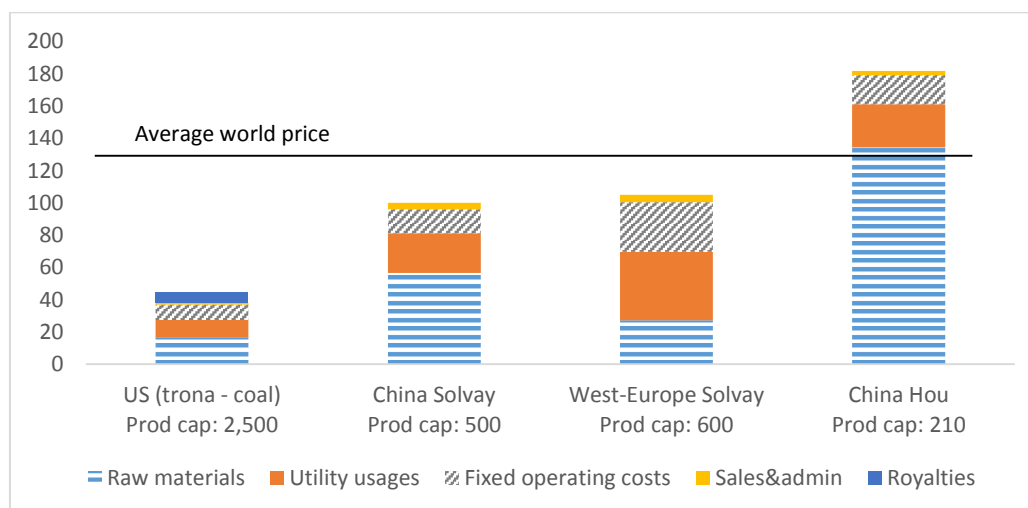
It is currently unclear which types of emissions (energy and/or process emissions) will be covered by the ETS, how high carbon prices are expected to be and which tools to alleviate ETS costs will be put in place.

The climate mitigation policies announced in the US so far, such as the Clean Power Plan, are not expected to affect soda ash plants, as the focus of these policies is on power plants (EPA, 2015). Turkish climate policies suggested until 2030 in the country's Intended Nationally Determined Contribution are not expected to affect soda ash plants significantly.

## 1.6 Production costs

The production costs for one tonne of soda ash vary across the main producing regions and the production process that is used. Production costs of one tonne of soda ash in the US (trona process), Western Europe (Solvay process) and China (Solvay and Hou processes) are compared in Figure 6.

Figure 6. Comparison of cash costs per tonne of soda ash across regions (China Solvay = 100, with an indicative average world soda ash price)



Notes: Production capacities per plant are added in thousands of tonnes per year.

**Raw materials** for the different processes:

US-trona: trona. West Europe and China Solvay: salt brine, limestone and coke. China Hou: salt, ammonia, carbon dioxide.

**Utility usage** for the different processes:

US-trona: coal for electricity and low pressure steam. West Europe and China Solvay: electricity and low pressure steam. China Hou: electricity, low pressure steam and cooling water.

**Fixed operating costs** for each region:

Labour, maintenance, overhead, and taxes and insurance. The latter three are estimated as a function of plant size and total fixed investment (TFI).

**Sales and Admin** is a fixed percentage of TFI for each region. US and EU: 0.6% and 0.9% for China

**Royalties** (US only) is the royalty paid to the US Bureau of Land Management, fixed at 6% of selling price.

Source: IHS (2015).

One can draw three main findings from Figure 6:

- 1) US trona-process soda ash has far lower production costs compared to Solvay and Hou soda ash. US trona-process soda ash raw material costs and utility bills per tonne are significantly lower than the EU-Solvay and China-Solvay costs. China-Hou raw materials and utility costs are the highest of all production processes. These differences are caused by two raw

materials-related factors: a) trona prices are considerably lower than limestone and salt brine prices and b) ammonia consumed in the Hou process is relatively expensive.

- 2) Solvay-process soda ash in China and the EU have similar total production costs, even though there are large differences between these two regions in the make-up of those production costs. First, utility costs (steam and electricity) are significantly higher in the EU than in China, and second the price of salt is more than three times as high in China.

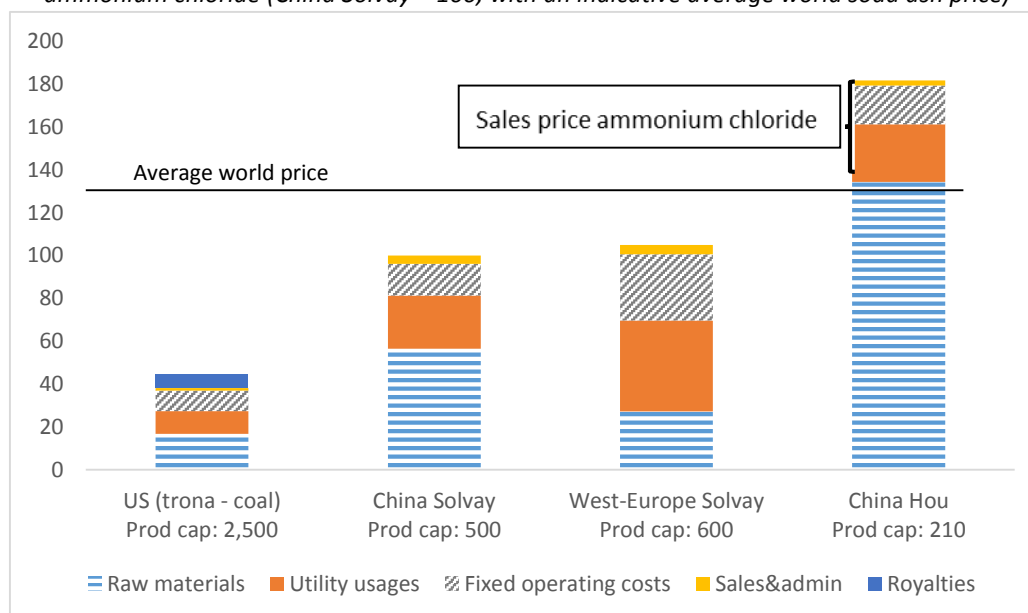
These two factors cancel out part of the production costs differences between Solvay-process soda ash in the EU and China.

- 3) Hou-process soda ash is significantly more costly to produce. The ammonia consumed in the Hou-process accounts for 75% of the raw materials cost. In the Solvay process, ammonia is continuously recycled, which means that Solvay-process soda ash does not entail this considerable cost.

As mentioned above, however, the Hou process also has a by-product: the fertilizer ammonium chloride. The sale of this co-product needs to be taken into account when analysing the different production cost structures. While Figure 6 shows that Hou-process soda ash is far more expensive to produce, Figure 7 shows that a part of that difference is mitigated by the sale of ammonium chloride.

At the present time, however, the sales price of ammonium chloride is historically low<sup>2</sup> (IHS, 2015). The sales price of ammonium chloride used in Figure 7 is an indicator of the average price throughout 2014 (approximately 70 USD per tonne). However, the price started recovering in the summer of 2015, if this trend continues Hou-process soda ash will become more competitive versus Solvay-process soda ash.

Figure 7. Comparison of cash cost per tonne of soda ash across regions, including the current sales price of ammonium chloride (China Solvay = 100, with an indicative average world soda ash price)



Source: IHS (2015).

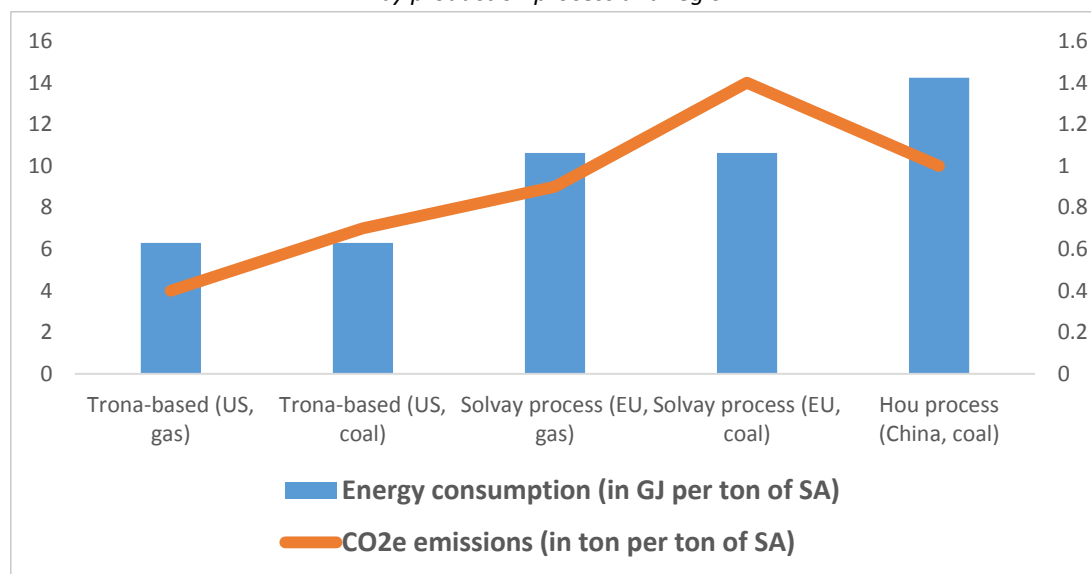
<sup>2</sup> In the spring of 2015 it dropped to around \$50 per tonne, down from more than \$180 per tonne at the end of 2013.

## 1.7 Climate change impacts of soda ash production

The environmental impacts of soda ash production depend on two factors: the production process and fuel used, as shown in Figure 8. Soda ash production using the Solvay or Hou process requires significant energy in the form of heat or steam. The production of this steam is the main determinant for explaining the differences in GHG emissions between plants within the same process.

Trona-process soda ash consumes less energy and emits less GHGs. As can be expected, coal-fired Solvay plants emit significantly more GHGs per tonne of product than gas-fired plants. However, current low prices of coal and high EU gas prices have led to coal-fired soda ash being more competitive. Two recently closed soda ash plants were gas-fired.

Figure 8. Energy consumption (left-hand axis, bar) and GHG emissions (right-hand axis, line), by production process and region



Source: Ansac (2010).

Figure 8, however, does not show the full picture; some trona mines emit methane. Mining emissions narrow the gap with the Solvay process in terms of emissions intensity.

Total emissions from the EU soda ash sector equalled approximately 10 million tonnes of carbon equivalent emissions (CO<sub>2</sub>e) in 2009. Emissions intensity data per EU plant were compiled by Ecofys and updated after a review of the scope of the emissions taken into account for that study (Ecofys, 2009b). These updated numbers are currently still confidential.

The main findings of the Ecofys study are as follows:

- The most emissions-intensive plant in the EU emitted more than 2 tonnes of CO<sub>2</sub>e per tonne of soda ash, and is an outlier. Other emissions-intensive plants emit between 1.3 and 1.4 tonnes of CO<sub>2</sub>e per tonne of soda ash.
- The least emissions-intensive plant emitted about 0.7 tonnes of CO<sub>2</sub>e per tonne of soda ash. The average emissions intensity was 1.05 tonnes of CO<sub>2</sub>e per tonne of soda ash.
- The differences in emission intensity are largely due to the fuel used, with coal-fired plants emitting more than gas-fired plants.

The best performers emit 30% less than the sector average and are gas-fired plants. The worst performers (not counting the outlier) emit up to 40% more than the sector average, and are coal-

fired. The remaining plants are spread out between the best and worst performers, and use a combination of gas and coal (Ecofys, 2009b).

## **1.8 Conclusion**

Soda ash is an important commodity that is internationally traded. It is mainly produced in three regions with significant exports to South-East Asia, South-Asia, Latin-America, Africa and the Middle East.

The EU and China produce mostly for their domestic market. The US is the main exporting region because trona-based soda ash is less energy and emissions-intensive and has a competitive advantage due to lower production costs. US trona-process soda ash is by far the cheapest to produce, and its producers can use this competitive advantage: it can be considered the baseload global supplier of soda ash.

However, global deposits of trona are limited and insufficient to supply the world market for soda ash. Currently 23% of global capacity is trona-based. Therefore the more energy- and emissions-intensive Solvay and Hou-based soda ash are necessary to meet total demand.

Countries that do not have significant soda ash production capacities (mostly developing countries in Latin America and South Asia), and that are not supplied by the US, import soda ash from the EU and China. EU Solvay and China Solvay are at a similarly competitive position, and although the Hou process is currently at a competitive disadvantage, it could regain a more favourable position as the price of ammonium chloride recovers. Currently both regions have an overcapacity of soda ash production.

This competitive balance, however, could be distorted by asymmetrical climate-change mitigation policies. If climate-change mitigation policies cause additional costs for soda ash producers in one region, but not in other regions, this causes a change in competitive balances. While China is planning on launching its national ETS in 2017, at the moment climate change policies are still asymmetric between the EU and China.

While these two regions are characterised by comparable production costs, one of the factors affecting their relative competitiveness is asymmetrical climate change mitigation policies. While the EU has placed a price on GHG emissions for soda ash producers, this is currently not yet the case for all Chinese producers.<sup>3</sup>

However, this asymmetry in coverage of GHG pricing mechanisms could change in the coming years; the Chinese national ETS is planned to be launched by 2017. Carbon-intensive chemical installations, such as soda ash plants, are planned to be included (ICAP, 2015b), although it remains to be seen if the GHG reduction efforts, carbon prices and cost mitigation measures will be comparable between regions. This depends on the implementation details, and therefore, the impacts of the Chinese national ETS. These details are currently not publically available to the general public.

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<sup>3</sup> Currently soda ash plants are covered by two of the Chinese pilot emissions-trading schemes: Shanghai and Tianjin (Carbon Pulse, 2015a). Assessing the cost impact of these pilots, however, is challenging and falls outside the scope of this case study.



## **2. Climate change mitigation policies**

This section chapter analyses various climate change mitigation policies from the three main soda ash-producing regions. Globally the number of direct and indirect climate change policies impacting the soda ash sector is limited.

The case study focuses on EU policies and especially the EU emissions trading scheme (EU ETS). The main reasons for focusing on the EU and the EU ETS include:

1. Information on policies and impacts is available,
2. It is a major soda ash-producing region and
3. The EU ETS is the flagship climate change policy.

The overviews of climate change mitigation policies in the United States and China presented are not exhaustive overviews of all climate change mitigation policies in those countries, but should more be seen as a superficial but indicative analysis of climate change mitigation policies that impact the soda ash sector in those countries.

### **2.1 *United States***

#### **2.1.1 *Prevention of Significant Deterioration (PSD) permitting program***

The Environmental Protection Agency (EPA) maintains a PSD permitting program. Plants need a permit to emit certain types of gases, including GHGs. Therefore it is a direct climate change policy. Plants only receive a PSD permit if they meet certain emissions limits determined by sectoral Best Available Control technologies of emissions (EPA, 1983).

However, the permits are grandfathered to existing plants: as long as they are not modified significantly, they continue to be licensed (EPA, 2011 and Mangino, 2010). This causes a perverse incentive: companies that wish to upgrade their plant need to apply for a new permit. This encourages continuation of the status quo and discourages GHG-reducing investments. Only investments that repay the costs of compliance for a new PSD permit, such as energy efficiency projects, will be undertaken.

### **2.2 *China***

#### **2.2.1 *Chinese National and Pilot ETS***

Details on the Chinese national ETS planned for 2017 remain scarce. However the Chinese government has announced that emissions-intensive installations in the chemicals sector, such as soda plants, are to be covered by the emissions trading scheme (ICAP, 2015a). However it is currently unclear which types of emissions will be included: emissions related to energy production and/or process emissions (Carbon Pulse, 2015a).

Soda ash plants are currently covered by two pilots: Tianjin and Shanghai (ICAP, 2015c). The Guangdong pilot is set to expand into the chemical industry in 2015 or 2016, but it remains to be announced whether soda ash plants will also be included (Carbon Pulse, 2015b).

However, due to the scarcity of information on the implementation of the pilots and available data, Chinese climate change policies are not further taken into account in this case study.

### **2.3 *European Union***

As mentioned above, the EU and its climate change policies are the focus of this case study. Three climate change policies are examined: the industrial emissions Directive, the renewable energy

Directive and the EU ETS. The main focus of this case study is on the EU's flagship climate change mitigation policy: the EU ETS. This policy is therefore analysed more in depth, while the industrial emissions Directive and the renewable energy Directive are not considered in chapters 3 and 4.

### *2.3.1 Industrial Emissions Directive*

The industrial emissions Directive (IED) is the successor of the integrated pollution prevention and control (IPPC) Directive and deals with pollution from various industrial sources, including emissions to air, water and land, generation of waste, use of raw materials and restoration of the site upon closure (European Commission, 2010b). Operators of industrial installations are required to hold an integrated permit issued by national authorities. More than 50,000 installations are covered by the Directive.

It is not a direct climate change policy as GHGs do not fall under the Directive; this would cause an overlap between the IED and the EU ETS. It does impact GHG emissions indirectly: one of the main strategies to comply with IED emissions standards is through revamping industrial boilers and ovens. This allows more efficient burning and reduces a wide variety of emissions including GHG emissions. However, this policy is not discussed further in this case study because the impacts of the IED cannot be clearly allocated to climate-change mitigation objectives.

### *2.3.2 Renewable Energy Directive*

*The renewable energy Directive* establishes a policy for the production and promotion of energy from renewable sources in the EU. The EU-wide objective is to fulfil at least 20% of total EU energy needs with renewables by 2020. This target is split between individual national targets, ranging from 10% (Malta) to 49% (Sweden). Each EU member state also has the obligation to reach a 10% share of renewables in transport (through biofuels).

The renewable energy targets can have significant impacts on energy prices, depending on how each member state chooses to reach those targets. For example, feed-in tariffs increase the price of electricity by guaranteeing these projects a price (or tariff) for the electricity they produce. This tariff is typically higher than wholesale electricity prices. Its impacts on the soda ash sector are also indirect, as soda ash plants are typically not electricity consumers, but some produce electricity as a by-product of steam generation. The renewable support measures can therefore be considered as subsidies for their competitors.

### *2.3.3 EU ETS*

The EU ETS is the flagship EU climate change policy. This policy is discussed more in detail in this chapter and in the following chapters, which address the impacts of climate change policies and the mitigation of those impacts.

#### **A. Overview**

The EU ETS Directive (European Commission, 2003) established a cap-and-trade system in 2005 as a cost-effective tool to reach the GHG targets to which the EU had committed itself. It is the EU's flagship climate change policy. The EU ETS was expanded to the non-EU members of the European Economic Area – Lichtenstein, Norway and Iceland – in 2007.

The EU ETS compliance is managed at the installation level. More than 11,000 installations in the manufacturing and power-generation sector and aviation within the borders of the EU and EEA are covered by the scheme. Although the emissions of several gases are covered by the scheme, the

large majority is carbon dioxide (CO<sub>2</sub>), and therefore all gases are converted into CO<sub>2</sub> equivalent units, according to their warming potential (known as CO<sub>2</sub>e).

Each year, each installation must surrender a number of emissions permits equal to its carbon emissions during the past year. European Union Allowances (EUAs) and other international units are compliance units and represent one tonne of CO<sub>2</sub>e emissions. This policy thereby seeks to extend the polluter-pays principle to GHG emissions.

The total cap for emissions is equal to the total amount of EUAs made available each year through free allocation or auctioning. Beneath that cap, market participants, including covered installations, are free to trade. This is meant to maintain the cost-effectiveness of emissions-reductions by ensuring that the cheapest reductions will be undertaken first. The total cap of the EU ETS is set to decrease every year by a linear reduction factor of 1.74%.

## B. Key Provisions

The EU ETS is based on the principle that operators of industrial and power installations covered by the EU ETS Directive surrender allowances to cover their emissions. The major characteristic of the functioning of the ETS in the third – current – phase is an increase in auctioning of allowances – more than 40% of all allowances will be auctioned (including full auctioning for the power sector). Energy-intensive industries, however, continue to receive a large part of the allowances they have to surrender for free, and will have to buy any shortfall at auctions or in the market.

The allocation to emissions-intensive industries is largely determined by using benchmarks, established per product, according to the Benchmarking Decision (European Commission, 2011). In general, the average carbon-intensity of the 10% best performers represents the benchmark for allocating free emissions. Each installation producing the same product has the same benchmark and receives the same amount of free allocation per produced unit. Installations that are more emissions-intensive than the benchmark thus receive a smaller percentage of free allowances relative to their total emissions than less emissions-intensive installations. The former are thereby encouraged to catch up to their best-performing peers. This approach also rewards early action by industry towards reducing emissions.

The benchmarks are determined as the number of allowances received per tonne of production at the installation. However the level of production at an installation is based on historical levels: the median production during the period from 1 January 2005 to 31 December 2008, or, where it is higher, on the median production during the period from 1 January 2009 to 31 December 2010. Changes in production are currently not taken into account, unless production is scaled back to less than 50% of the historical level. Production increases beyond historical levels (and thus emissions increases) also fall outside the scope of the benchmark and therefore are not taken into account during free allocation of allowances.

Free allocation for all manufacturing industries under the cap is granted at the 80% level of the benchmark in 2020, a share that is set to decrease to 30% in 2020 for sectors not deemed exposed to the risk of carbon leakage. Sectors that are deemed to be at risk of carbon leakage, and which are listed in the Carbon Leakage List (European Commission, 2009c and European Commission, 2014), receive free allowances up to 100% of their benchmarks. The list was thoroughly revised in 2014. Free allocation is done according to the following formula:

$$\text{Allocation} = \text{benchmark} \times \text{historical activity level} \times \text{carbon leakage exposure factor} \\ \times \text{cross-sectoral correction factor}$$

Where the historical activity level (or production) is installation-specific, and the carbon leakage factor is 100% for the soda ash sector. The cross-sectoral correction factor (CSCF) guarantees that the sum of the free allocation proposed by each member state does not exceed the EU ETS-wide cap on free allocation. The CSCF determines the proportion of the proposed free allocation that is granted to each installation that is eligible to receive allocation and will decrease yearly to circa 82.44% in 2020.

### C. Relevance for the soda ash sector

The soda ash sector is considered one sector together with sodium bicarbonate production since it entered the EU ETS in Phase 3 (2013). The soda ash sector is on the Carbon Leakage List.

The benchmark, which was determined in 2009 on the basis of 2005 emissions, was set at 0.843 tonnes of CO<sub>2</sub> per tonne of soda ash. In practical terms, this means that soda ash plants receive 0.843 allowances per tonne of soda ash they produce, at the level of their historical level of production (Ecofys, 2009b). In the longer term this will decrease as the cross-sectoral correction factor decreases up to 2020.

It is likely that plants currently receive more than 0.843 allowances per tonne of soda ash produced. Operating rates have decreased significantly since the base years for the determination of the benchmarks (2005-10). As long as at least 50% of historical production is maintained, allocation is not flexibly adjustable to changes in production levels. Capacity expansions, however, are taken into account during the allocation of free allowances.

## 3. Impacts of climate change mitigation policies

This chapter analyses the economic, social and environmental impacts of climate change policies on the soda ash sector. Quantifying these impacts is a challenging task due to:

- a) the difficulties linked to gathering sensitive company and plant-level data in a competitive sector and
- b) the scarcity of data identifying and measuring impacts, including the follow-up response to impact assessments.

This case study does not aim to assess the efficiency and efficacy of climate change policy in terms of GHG reductions, but rather it intends to examine the management of the impacts of those policies. We have observed positive and negative impacts, which can be intended or unintended. All impacts of climate change policies are important, but it is clearly the negative unintended impacts that need management. Management of the impacts of long-term mitigation policies is necessary in the short term in order to enable a smooth transition to a low-GHG economy.

### 3.1 **Economic impacts of the EU ETS**

#### 3.1.1 *Positive economic impacts*

The main positive economic impact of the EU ETS for the soda ash sector is that it increases incentives for continued low-GHG innovation. This could lead to an improved competitive position as carbon-pricing policies spread globally in the longer term. The experience that EU soda ash producers acquire in decreasing emissions intensity of production could leave them with a competitive advantage against global competitors using the Solvay and Hou processes. The latter will have to

catch up with implementing low-GHG production technologies. The energy and emissions advantages of trona-based soda ash are significant and will remain so in the medium to longer term.

### 3.1.2 *Negative economic impacts*

This section identifies and assesses potentially negative economic impacts of energy sector policies on the soda ash sector. These could take the form of possible additional costs, trade distortions, reduced investments or adverse implications for the global economy. These elements are discussed in detail below.

#### 1. **Additional costs**

The additional costs caused by the EU ETS that can worsen the current competitive position of EU soda-ash producers take the following forms:

- **Direct costs:** These entail the cost of buying EUAs for compliance, which are either freely allocated or bought on the secondary market. This is currently negative for some plants, however, as soda-ash plants have been oversupplied the previous two years. This situation could change in the medium term, however. The direct cost is an intended impact for soda ash producers.
- **Indirect costs:** The compliance cost of sectors that produce inputs for the soda-ash sector are passed through. Indirect costs passed through from steam-producing facilities are the most relevant for the soda ash sector – and the most significant. These facilities are generally short and have to buy EUAs on the secondary market. Indirect costs is an intended impact for soda ash producers.
- **Administrative costs:** Monitoring, reporting and verification (MRV) obligations create costs that increase production costs. These costs are deemed intended to some extent, as by enabling the collection of data and the compliance of installations they are necessary for the functioning of the ETS. Administrative costs are of course to be kept to an absolute minimum for both the installations under the EU ETS as the ETS's governing bodies.

#### A. Direct costs

At the end of each year, installations surrender EUAs to match their CO<sub>2</sub> emissions in that year (in tonnes). Essentially, the cost of compliance is the difference between the amount of EUAs each installation needs to surrender and the number of free allowances allocated, multiplied by the price of allowances purchased (Renda et al., 2013a and 2013b). Installations producing soda ash receive free allowances, as they are considered at risk of carbon leakage. These free allowances are further discussed under the next chapter on mitigation of impacts. Any shortage of allowances can be purchased from auctions or on the secondary market.

Note that direct costs are an intended impact of the EU ETS, as they aim to internalize GHG emission costs into production processes and thereby incentivizing low GHG production.

Using historically verified emissions and CO<sub>2</sub> prices, it is possible to estimate direct costs for the EU soda-ash sector. In this approach the following formula is used:

*Direct carbon cost (euro)*

*= Verified emissions (tonnes of CO<sub>2</sub>) x carbon price (euro per tonne of CO<sub>2</sub>)*

Where:

- Verified emissions are emissions reported for each EU soda ash installation in the EU Transaction Log: the data platform where emissions and allowances per installation are made public by the European Commission (2015b)
- Carbon price is the historical yearly average EUA price
  - o 2013-14: yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange (2015), a prominent platform for the trade in EUAs

Note that the EUA price used is a proxy and is likely to produce imperfect results. A plant-by-plant analysis of transfers and trading strategies to see who sold what, when and at which price is necessary to fully understand carbon prices and the exact impact of the EU ETS.

This approach does not take indirect costs into account, and is therefore not an accurate description of the real costs faced by EU soda ash producers. In reality most plants are integrated with their heat suppliers, however, plants are administratively split up into sections in the EU ETS registry, with each part – or installation – defined by its main purpose. Therefore soda-ash plants can be split into a soda-ash installation and a steam-generating installation on paper, even though these two installations are regarded by the company operating them as one single plant.

On the level of installations identified in the EU TL as soda-ash producing installations, all but two were oversupplied to various degrees in the 2013-2014 period. Total oversupply was 4.8 million EUAs (European Commission, 2015b). The emissions reported in the EU Transaction Log (EU TL) are however significantly lower than the sector averages as reported in the benchmarking study (Ecofys, 2009b): 0.6 versus 1.05 tonnes of CO<sub>2</sub> per tonne of soda ash. This means that a significant source of emissions is not covered by this approach, and neither are the costs associated with it: the indirect costs.

## B. Indirect costs

Plants producing and selling electricity or heat face increased production costs through their ETS compliance costs. They pass on these costs to their respective customers via higher energy rates. Industrial electricity and heat consumers therefore face an extra cost because of the cost of CO<sub>2</sub> embedded in electricity and heat prices. This is an additional cost, which they may not be able to pass on fully to the ultimate consumers if they are active in a globally competitive sector. Indirect costs should be considered an intended impact of the EU ETS, as they aim to internalizing upstream GHG emissions costs into production processes, thereby incentivizing the sourcing of low-GHG intensive intermediate goods, raw materials and energy.

Note that indirect costs have been passed through to soda-ash installations since the inception of the EU ETS in 2005 as power plants and large combustion installations were covered from the start.

While soda ash is not an electricity-intensive sector, a number of installations do obtain heat from external sources, often combined heat and power (CHP) plants. Note that the word ‘external’ refers to the way the EU ETS is structured.

The pass-on rate of the CO<sub>2</sub> cost for producing electricity and heat is a number that is contested and may vary significantly between member states. In this case study, the pass-on rate is assumed to be one, but this is a conservative assumption and may overestimate actual indirect costs.

The main difficulty for calculating precise indirect costs is that individual soda-ash installations have various different relationships with their providers of steam and electricity. As mentioned they might only be two installations on paper but be operationally one plant. On the other hand, several soda-ash producers have arrangements with the facilities that provide heat, such as long-term contracts or investment agreements.

Additionally a number of heat-producing installations linked to soda ash installations are Combined Heat and Power (CHP) installations. These CHP installations produce heat for one or more installations (such as the soda ash installations in question) and co-produce power that is sold to the grid. This further muddles the picture on indirect costs as the pass-through of EU ETS costs to either the consumers of heat or power is sensitive and confidential company-level information.

Due to the lack of plant-specific data on steam and electricity consumed per tonne of soda ash produced, it is challenging to accurately calculate indirect EU ETS costs for soda-ash installations. While it has been possible to map out soda-ash installations and heat- and/or power-producing installations linked to them, it has proven impossible to independently verify what share, if any, of EUA costs has been passed on to the soda-ash installations.

It is clear, however, that these heat- and/or power-producing installations faced EUA shortages. While they emitted just under 41 million tonnes of CO<sub>2</sub> since the start of Phase 2 until the start of 2015, during that same period these installations received a total of approximately 34.5 million EUAs. This means that they were nearly 6.5 million allowances short. Although it is impossible to estimate precisely what percentage of this shortfall in EUAs was passed on to soda-ash producers without access to contracts between heat providers and soda-ash installations, it is safe to assume that a significant part of it was passed through. An estimation of expected costs can be found below under Total additional costs.

### C. Administrative costs

Two kinds of administrative costs arise under the EU ETS: one-off costs for the start-up of the process, and recurring Monitoring, Reporting and Verification (MRV) costs. The start-up costs are caused by the investments necessary for monitoring compliance. For illustrative purposes, the infrastructure needed for the correct measuring of emissions would represent a one-off start-up cost (European Commission, 2012). MRV costs are the additional burdens placed on installations for continued compliance with monitoring duties, for example the wages of the staff dealing with the administrative aspects, or the cost of hiring a verifier to check emissions measurements.

Data on administrative costs are challenging to compile, as they are determined by sensitive plant-specific data. However, CEPS has in the past conducted in-depth studies on EU ETS costs, which included administrative costs. Industrial installations in the steel sector, the aluminium sector and downstream aluminium sector faced administrative costs between €0.02 and €0.93 per tonne of product. However, the administrative costs for larger plants, such as steel plants, are between €0.10 and €0.13 per tonne of product.

We assume that administrative costs for soda-ash plants are on the same order of magnitude: approximately €0.10 per tonne.

#### D. Total EU ETS costs

In order to estimate the total additional EU ETS costs, the average the amount of CO<sub>2</sub> that is on emitted during production of one tonne of soda ash is multiplied by the estimated costs of emission. Administrative costs are then added. This approach therefore takes direct, indirect and administrative costs into account. In this case total additional costs are equal to:

$$\begin{aligned} & \text{Total carbon cost} \left( \frac{\text{euro}}{\text{tonne of soda ash}} \right) \\ &= [\text{Carbon intensity of production} \left( \frac{\text{CO}_2}{\text{tonne of soda ash}} \right) \\ &\quad - \text{Soda ash benchmark} \left( \frac{\text{CO}_2}{\text{tonne of soda ash}} \right)] \\ &\quad \times \text{Carbon price} \left( \frac{\text{euro}}{\text{tonne of CO}_2} \right) \\ &\quad + \text{Administrative costs} \end{aligned}$$

Where:

- Carbon intensity of production is an sector average.
- Soda ash benchmark is the number of allowances per tonne of historical production that each soda ash plant receives. For Phase 3 it is set at 0.843 EUAs per tonne of soda ash.
- Carbon price is a fixed and exogenous price of emissions allowances.
- Administrative costs are estimated at €0.1 per tonne of soda ash.

This approach allows us to look at potential impacts of any carbon-pricing mechanism, using carbon prices that are deemed plausible in the longer term. It is, however, a simplification of how the EU ETS functions.

Theoretical carbon costs for three different types of soda ash plants and two EUA prices are estimated in Table 1 below. Two EUA prices are chosen: an approximation of the current EUA price (€8) and the EUA price used by the European Commission for assessing the longer-term impacts of the EU ETS (€30) (European Commission, 2014a).

The technical – installation level – details of the EU ETS and potential future reductions in carbon intensity of soda ash production are however not taken into account. Table 1 is therefore not an accurate estimation of the historical and future economic impacts of the EU ETS on soda ash plants.



*Table 1. Total additional costs per tonne of soda ash produced (direct, indirect and administrative costs) for plants with different emissions intensities, for two EUA prices, with estimated percentages of current cash costs (approx. €150 per tonne of soda ash) and free allocation at benchmark level.*

Carbon price	Carbon cost for <b>low-emissions-intensive plant</b> (0.8 tonne of CO <sub>2</sub> per tonne of soda ash)	Carbon cost for <b>medium emissions-intensive plant</b> (1.15 tonnes of CO <sub>2</sub> per tonne of soda ash)	Carbon cost for <b>high emissions-intensive plant</b> (1.4 tonnes of CO <sub>2</sub> per tonne of soda ash)
€8 per EUA (or 1 tonne of CO <sub>2</sub> )	<b>€-0.24</b> Approx. <b>0.2%</b> of production costs	<b>€2.56</b> Approx. <b>2%</b> of production costs	<b>€4.56</b> Approx. <b>3%</b> of production costs
€30 per EUA (or 1 tonne of CO <sub>2</sub> )	<b>€-1.19</b> Approx. <b>1%</b> of production costs	<b>€9.31</b> Approx. <b>6%</b> of production costs	<b>€16.81</b> Approx. <b>11%</b> of production costs

*Notes:* The Ecofys (2009b) benchmarking study determined the emissions intensity of European soda-ash plants. The emissions intensities chosen for this table are sourced from that study, with two major differences:

- 1) The emissions intensities in the study were reconsidered by the European Commission and subsequently raised. This has been taken into account here.
- 2) The most emissions-intensive plant in the benchmarking study is considered an outlier and is not taken into account here.

*Source:* Authors' own calculations.

As expected, the impact of the EU ETS on soda-ash plants depends on both the carbon intensity of production and the price of EU allowances. The least emissions-intensive plants in the EU emit approximately 0.8 tonnes of CO<sub>2</sub> per tonne of soda ash. Because their carbon intensity is lower than the benchmark, they receive more allowances than necessary to cover their emissions. The EU ETS therefore has a positive impact on the plant's costs.

The picture is very different for the most-emissions-intensive installations in the EU (carbon intensity of production of 1.4 tonnes of CO<sub>2</sub> per tonne of soda ash). These installations emit 50% more than the benchmark, and therefore have to buy additional EUAs. Direct costs in the longer term could run up to €16.71 per tonne of soda ash for these GHG-intensive plants, or 11% of the current production cost of soda ash. Direct costs are linearly dependent on the carbon intensity and the EUA price in this approach, and therefore plants that emit a relatively higher amount of GHG also face an equivalently higher carbon cost.

Note that this theoretical carbon cost is a simplification, and does not take three important factors into account:

- 1) Historical production levels. This currently works to the advantage of soda-ash plants, but if demand picks up sufficiently to push production beyond the historical levels used in the benchmarking exercise, this will work against the sector.
- 2) The pass through of EU ETS costs. Many EU plants produce heat (necessary for the Solvay process) and electricity as a by-product. This electricity is sold to third parties, and EU ETS costs could be passed in electricity prices.
- 3) Cross-sectoral correction factor. This will reduce the amount of free allocation yearly up to 2020.

## E. Conclusion on EU ETS costs

Currently there is no clear evidence that the EU ETS has caused additional costs nor gains for the soda ash sector in general. At the sector level, soda ash was oversupplied and accumulated a total of 4.8 million allowances. On the plant level, two installations did not receive sufficient EUAs to cover their emissions. Installations supplying heat and/or power to soda ash installations had a shortfall of 6.4 million allowances, and will have passed a share of the cost of buying EUAs through to the soda ash installations.

How large that share is requires additional research and falls outside the scope of this case study, it is however deemed to be significant due to the relationships between soda ash plants and their heat suppliers, and the way the EU ETS registry separates the two types of installations.

The administrative burden of complying with the EU ETS also caused a minor cost for soda-ash producers.

But is the past a good representation of the future? The EU ETS is still relatively young, and soda ash has only come under its governance in the last two years. These two years were characterised by both low EUA prices and low sector-wide operating rates.

Free allocation is made on the basis of historical production levels in the benchmark years (2005 and 2006), when operating rates were over 90% in Western Europe, they have since fallen to just over 70% in 2013. Once operating rates pick up and approach or even surpass the 2005-06 levels, direct costs for the sector will also pick up.

Additionally, free allocation will continue to reduce annually due to the cross-sectoral correction factor. By 2020, it will reduce free allocation by nearly 20% under the benchmark. It is safe to assume that if the sector is not yet short, it will be by 2020.

The estimation of the theoretical or average marginal carbon cost shows that at 100% operating rates, and different levels of EUA prices, direct costs could become very significant for medium and high carbon-intensive plants, running up to 11% of current production costs for the most emissions-intensive plants and the highest EUA price used in the estimation. At the same time, low-emissions plants will continue to receive more allowances than necessary for compliance.

As is made clear above, direct costs are linearly related to the emissions intensity of the plant. Because the main source of GHG emissions in soda ash plants is caused by the choice of fuel (coal or gas), it is possible to mitigate the EU ETS direct costs by switching from coal to gas. However, gas prices are currently far higher than coal prices in the EU, whereas this difference is markedly smaller in other regions. One tonne of Solvay-process soda ash needs 11.5 gigajoules (GJ) of energy input (ANSAC, 2010).

The price of natural gas in the EU is currently approximately €7.4 per GJ, while the price of coal stands at €2.7 per GJ (GDF-Suez, 2015). This means that switching from coal to gas increases energy bills by €54.05, or approximately one-third of production costs.

If this difference in energy prices persists, operators of soda ash plants will face a choice: either continue to use coal and pay the direct EU ETS costs, or switch to gas and pay the additional energy cost. Either way, EU producers of soda ash face a cost that non-EU producers do not face. In a highly competitive international market for the commodity, this means they will either lose market share or have to reduce margins.

Note that these EU ETS costs are intended impacts of the EU's flagship climate change policy. By internalizing the costs of GHG emissions, emission reductions are incentivized and revenue from auctioned allowances is mobilized. Though this is currently not the case, these revenues could be recycled in order to mitigate the unintended impacts of the EU ETS. These unintended impacts can either be found within the EU, or outside of the EU.

The unintended impacts in the EU mostly result from the inability of installations under the EU ETS to fully pass on costs to downstream users and consumers. The production cost increases because of direct, indirect and administrative EU ETS costs could lead to installations losing competitive position vis-à-vis installations in jurisdictions with less, or no, climate change related constraints. This may result in unintended economic impacts (such as reductions in trade, production or investment), unintended social impacts (such as loss of employment opportunities) and unintended climate policy impacts (such as carbon leakage).

Unintended impacts outside the EU results from the ability of installations to partially pass on EU ETS costs to downstream users and consumers outside the EU. Soda ash consumers in third countries, including developing countries, could face increased soda ash prices, which may be passed on to wider society in the prices of goods.

These unintended impacts are discussed in depth below.

## 2. Trade

The analysis of the direct, indirect and administrative costs has not provided a clear picture that the EU ETS has caused significant costs for the soda ash sector. Recent import and export data also do not reveal a clear indication that the introduction of the EU ETS in 2005 and the inclusion of the soda ash sector in 2013 caused unintended and significant trade distortions, as Figure 9 shows.

Figure 9. Exports and imports of soda ash in the EU, 2004-13 (000s of tonnes)

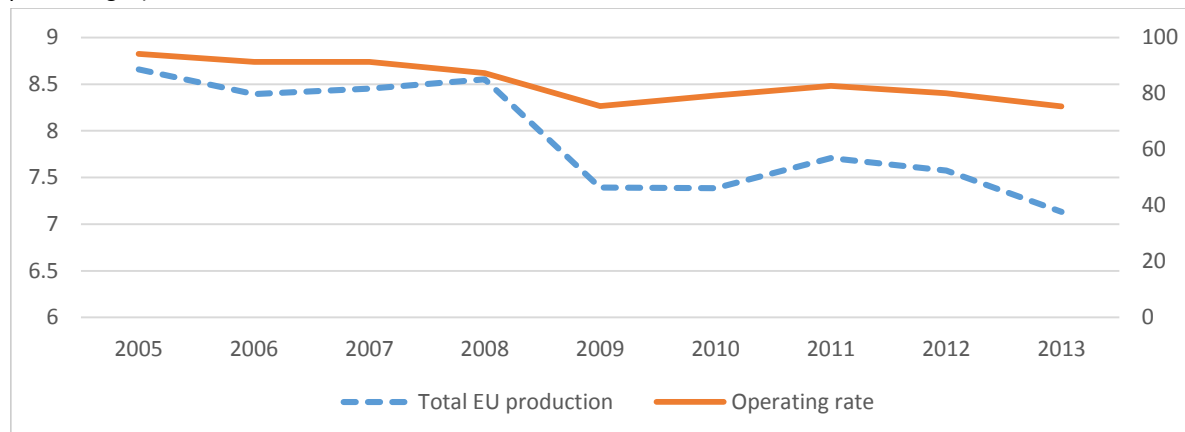


Source: IHS (2015).

It is likely that the relatively large year-on-year differences are caused by macroeconomic developments such as the economic and financial crises. However, it must be noted that in 2013 – the only year in Figure 8 during which soda ash was covered by the EU ETS – the EU's net exports did fall notably compared to the year before. However, this cannot be fully attributed to the EU ETS as direct and indirect costs in that year were not found to be significantly high. To conclude, as yet there is no clear indication that the EU ETS has impacted the EU's trade balance for the soda ash sector.

Figure 10 shows that the decrease in soda ash production predates the inclusion of the soda ash sector in the EU ETS. The decrease began in 2008 as the financial crisis unfolded, and has not recovered since then.

*Figure 10. EU production (left-hand axis, in millions of tonnes) and operating rates (right-hand axis, in percentages), 2005-13*



Source: IHS (2015).

### **3. Investment**

Investment in new capacity and in maintaining current capacity is markedly lower in the EU than in other regions. Two soda ash plants were closed in 2014 – one in Povoá, Portugal and the other in Winnington, UK, but the EU is not the only region that has recently seen soda ash plants close down. One Kenyan plant closed in 2014, one Japanese plant closed in 2015 and two Chinese plants were idled in 2015 (IHS, 2015).

However, it is the only region where capacity is expected to decrease significantly over the 2014-18 period. Closures in other regions are more than offset by investments in new plants. China alone is expected to increase its 2013 capacity by nearly a third: nearly 8 million tonnes of extra production capacity is expected by 2017 (IHS, 2015).

There is no clear indication that the lack of investments in capacity throughout the EU is an unintended consequence of the EU ETS and potential future costs it could cause. It is more likely that the ongoing economic difficulties and falling domestic demand are the root cause of this trend. Domestic demand for soda ash has fallen by nearly 1 million tonnes on a yearly basis between 2005 and 2014.

### **4. International economic impacts**

The European Commission's EU ETS impact assessments for the EU ETS take a wide variety of economic, environmental and social impacts of the EU ETS into account. However, the impacts beyond the EU are not analysed in detail. The first EU ETS-related impact assessment dates to 2008 (European Commission, 2008) and does not cover international implications beyond the competitiveness issues for domestic industry. Additionally the 2010 impact assessment accompanying the Benchmarking Decision for instance does not mention any international impacts (European Commission, 2010b). The 2014 impact assessment on the revision of the carbon leakage list (European Commission, 2014a) and the 2015 impact assessment on the Structural Reform proposal (European Commission, 2015a) addresses direct and indirect impacts and costs, but do not identify that these impacts can also be international in nature.

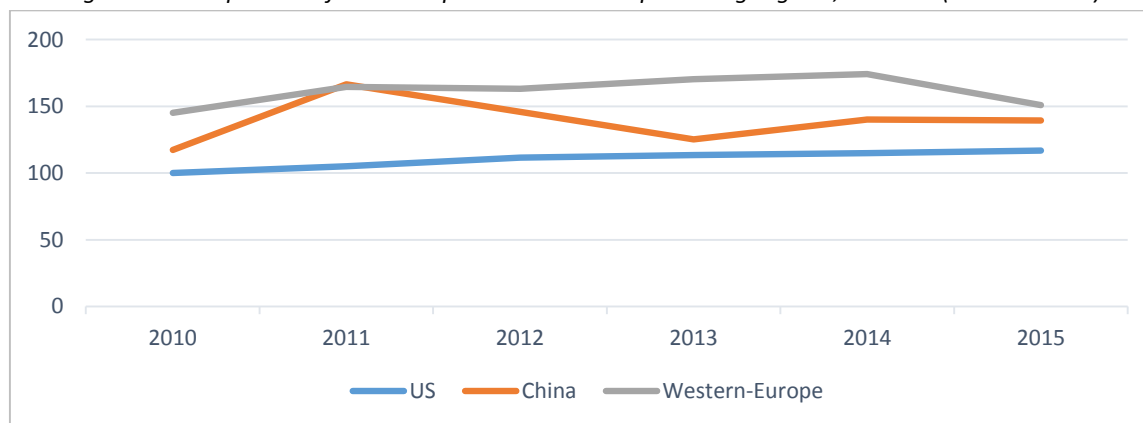
Generally these impact assessments focus on domestic impacts, but stop at the EU's borders. On the international level there is also a lack of procedures and governance structures that identify, measure, and mitigate the cross-border impacts of climate change mitigation policies. In that light, an estimation of the international impacts of the EU ETS is made.

The various additional costs for soda ash producers caused by the EU ETS are likely to increase global prices for soda ash, which increases production cost for downstream sectors – both in developing and developed countries – ultimately leading to higher prices of finished goods for consumers. We consider the international spillover effects to be unintended impacts of the EU ETS.

Downstream sectors – both in and outside the EU – can be impacted by the EU ETS costs that the EU soda ash sector potentially faces in the future. The various costs for soda ash producers caused by the EU ETS are likely to increase the sales price of EU soda ash. In the long run the margins in the market for an internationally traded commodity are minimal. EU producers will therefore either adapt their prices to the new costs or face closure.

Global soda ash prices will rise as a reaction to the price increases in the EU, whether these are caused by EU producers increasing their sales price, or supply falling because of closures. Currently uncompetitive non-EU producers, notably in China, will be able to enter the market as global prices increase. These higher soda ash prices are passed through downstream sectors such as glass and detergents, leading to higher production costs further downstream, for example, in the construction and car industries. Downstream sectors and ultimately consumers – both in developing and developed countries – face increased prices due to this domino effect. Figure 11 indicates that although there is no perfect correlation between EU and Chinese soda ash prices, in the mid to long term prices show the same trend.

*Figure 11. Comparison of soda ash prices in the main producing regions, 2010-15 (US 2010=100)*



Source: IHS, 2015.

Estimating the costs that are passed through a wide variety of downstream sectors, products and production processes is challenging. Therefore we present below a relatively simple example based on the flat glass sector.

The increase in the production costs of flat glass in developing countries that import soda ash from the EU can be described as:

$$\begin{aligned}
&\text{Flat glass production cost increase (in \% ) =} \\
&\quad \text{Soda ash share of flat glass production cost (in \% )} \\
&\quad \times \text{EU ETS soda ash cost increase (in \% of soda production costs)} \\
&\quad \times \text{Ability to pass costs through (in \% )}
\end{aligned}$$

Where:

- Soda ash share of flat glass production cost: soda ash is one of the most expensive raw materials used in the flat glass industry, and amounts to 60% of raw material costs. Raw materials make up approximately 22% of production costs for flat glass, meaning that soda ash alone accounts for more than 13% of flat glass production costs (Pilkington, 2010).
- EU ETS soda ash cost increase is the increase in the production due to theoretical EU ETS direct costs. For a medium emissions-intensive plant (1.15 tonnes of CO<sub>2</sub> per tonne of soda ash), production costs are increased by 2% for an EUA price of €8 and by 6% for a EUA price of €30, as described in Table 1.
- Ability to pass costs through: pass-through rates for the soda ash sector have not been studied previously. A recent European Commission impact assessment concluded that the chemicals sector as a whole is expected to be able to pass all costs onwards, on the basis of literature references focusing on some organic chemicals (European Commission, 2015a), however soda ash is an inorganic chemical. Ecorys (2008) estimated that the pass through of soda ash EU ETS costs to the flat glass industry amounts to €7.9 million annually in the UK alone.

However, we conservatively assume that only half of the soda ash EU ETS costs can be passed through; otherwise Chinese producers will step in, as operating rates are currently around 80% in China. The ability to pass costs through is therefore assumed to be 0.5.

Using the information above, we estimate that at an EUA price of €30 a tonne, this would increase production costs for flat glass by approximately 0.4%. This assumes that the soda ash is produced in a medium emissions-intensive plant.

A Vivid Economics report (Vivid Economics & Ecofys, 2014) analysed the pass-through ability of the flat glass industry and estimated that until 2020, the flat glass industry will be able to pass through 75% of EU ETS costs that have been passed through from the soda ash sector to the flat glass industry, wherever the glass plant is localised. This means that flat glass prices could increase by approximately 0.3%.

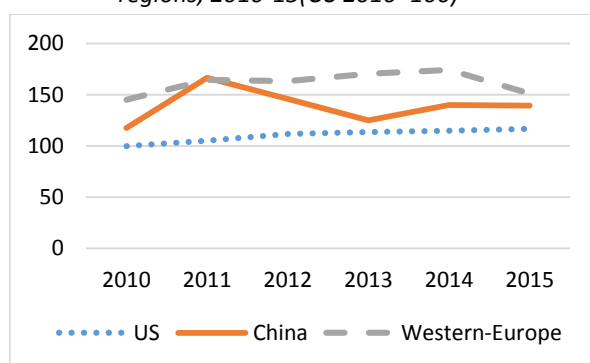
In these hypothetical circumstances, the EU ETS costs for the soda ash plant would be passed along the value chain to flat glass producers (both in the EU and outside the EU), which, in turn, pass 75% of their cost increase to their consumers, leading to an increase of up to 0.3% in the sales price of flat glass.

If we keep in mind that EU producers export a significant share of domestic soda ash production to developing countries (such as Brazil, India, Egypt, Indonesia and Morocco), flat glass producers and consumers in developing countries could be affected, as input prices are increased by the EU ETS.

This example is of course not an accurate description of the current reality; for instance EUA prices are not at currently at €30, but it is an indication of how costs could pass through the value chain to third-country producers. This dynamic is expected to influence production costs in domestic industries that are downstream from the EU and Chinese soda ash sector. This would weaken their competitive position vis-à-vis producers that source their soda ash from the US or other trona-based producers such as the US and Turkey.

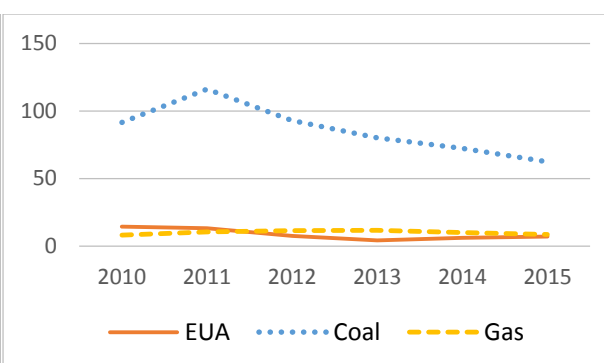
Figures 12 and 13 show that there is currently no clear correlation between the recent evolution in soda ash prices in the different regions and the evolution of some important cost factors, including the EU ETS. It might become possible to discern some correlation between these variables, as the EU ETS continues to operate and EUA prices increase.

Figure 12. Soda ash prices in the main producing regions, 2010-15 (US 2010=100)



Source: IHS (2015).

Figure 13. Energy and EUA prices, 2010-15 (\$)



Source: World Bank Commodity Price Data, ICE exchange.

### 3.2 Social impacts of the EU ETS

#### 3.2.1 Positive social impacts

Because soda ash plants in the EU are currently mainly coal-fired, the reduction in emissions that the EU ETS is meant to cause would have potentially positive health benefits as local air pollution is reduced.

#### 3.2.2 Negative social impacts

The EU ETS impact assessments include estimations of impacts of various policy options on employment in the EU. For example, the impact assessment accompanying the proposal for the EU ETS reform for phase 4 (European Commission, 2015a) estimates that the overall impact of the EU ETS on employment is limited. The 2030 impact assessment (European Commission, 2014b) shows that when the revenues of EUA auctions are recycled and if carbon pricing is extended to all sectors, climate change mitigation policies can lead to an increase in employment of 0.2% or 430,000 net jobs created in the EU by 2030.

A detailed analysis of the employment effects of the EU ETS on the soda ash sector has not been conducted to date. Some 22,500 people were employed in the soda ash sector in 2002 (European Commission, 2007), but it is unclear how employment in this sector has evolved since then. However, during the previous ten years, five soda ash plants have been closed down, with significant job losses as a result. The three most recent closures (Povoa in Portugal, Winnington in the UK and Ocna Mures in Romania) affected approximately 2,600 employees.

It is important to note that the five aforementioned closures cannot be attributed to climate change policies alone. Indeed, Tata announced that the closure of the Winnington plant was caused mainly by energy prices (Taylor, 2013). Four out of five plants were gas-fired, and faced higher production costs due to higher gas prices compared to coal-fired plants. The closures are therefore due to a long list of factors, including energy prices and climate change policies. However, carbon pricing is just one factor in a wider competitiveness story. The EU ETS can therefore not be considered as having had unintended negative impacts on employment in the EU soda ash sector.

### **3.3 Environmental impacts of the EU ETS**

#### **3.3.1 Positive environmental impacts**

The main positive environmental impact is the reduction of GHG emissions throughout the sectors covered by the EU ETS. This is an obvious positive impact as the EU ETS has a stated goal to reduce GHG emissions in a cost effective way.

While the emissions from sectors under the EU ETS have fallen significantly since the inception of the EU ETS, the share of that reduction that the EU ETS accounts for is estimated at only 21% for the 2005-12 period. The lion's share of emissions reductions in that period was caused by the slowdown of economic activity due to the economic and financial crises (Bel & Joseph, 2014).

#### **3.3.2 Negative environmental impacts**

Carbon leakage is frequently seen as the major unintended negative environmental impacts of climate change policies. Broadly speaking, carbon leakage can be defined as the displacement of economic activities and/or changes in investment patterns, that directly or indirectly cause GHG emissions to be displaced from a jurisdiction with GHG constraints, to another jurisdiction, with no or less GHG constraints (Marcu et al., 2013).

There are a number of factors that may enable asymmetric carbon policies to result in carbon leakage. These so-called 'carbon leakage risk factors' determine whether climate policies increase the carbon leakage risk for a product or a sector on the basis of two criteria: the size of the carbon cost and the ability of the sector to pass through carbon costs to other sectors or consumers.

In the EU ETS, the carbon costs that firms incur by complying with the EU ETS may undermine their competitive position. This could lead to demand or investment being relocated to other jurisdictions that have a lower or different carbon constraint. For the soda ash sector, that would mean that less emissions-intensive production in the EU would be replaced by more energy- and emissions-intensive production in for example China, where significant production capacity is currently idled, and Turkey. The relocation of EU soda ash production to China would therefore have a significantly negative environmental impact.

While the current global overcapacity in the soda ash sector points to a lack of the ability to pass through costs, especially if they are only incurred in one region. The European Commission impact assessment (European Commission, 2015a) indicates that the chemicals sector as a whole is deemed to have the ability pass on all costs to downstream sectors and consumers. This impact assessment, however, does not present any specific evidence for the soda ash sector or the ability to pass through costs in export markets.

Currently there is no evidence that carbon leakage has taken place as the EU ETS is too recent to discern significant different trade flows and investment patterns. Additionally, the expansion of carbon-pricing mechanisms could deter carbon leakage from happening. In the case of soda ash, the aforementioned Chinese National ETS is of particular importance. It is currently unclear how



stringent that ETS will be, which cost alleviation tools will be used and which parts of the chemicals sector will be covered by it.

### **3.4 *Conclusions on the impacts of climate change policies***

The EU has a number of climate change mitigation policies in place. The impacts of the industrial emissions Directive are too indirect to be attributed to climate change mitigation, and the renewable energy Directive impacts the soda ash sector indirectly through the combined production of heat and electricity. Both are considered beyond the scope of this case study.

The EU ETS, on the other hand, has the potential to significantly increase production costs for EU soda ash producers, depending on the EUA price and the emissions intensity of the individual plant. This is an intended impact of the EU ETS, as producers internalize the costs of GHG emission and low-GHG innovation and production is incentivized. Because of a global overcapacity, asymmetrical climate change policies could, however, have big unintended impacts on production, trade and investment in the jurisdiction enacting more stringent climate change policies. If constrained producers have the ability to pass cost increases through, costs could be passed on down the value chain and affect industries in third countries, including developing countries.

At the present time, however, there is no evidence to suggest that these unintended impacts are happening. The EU ETS has only been in operation for a short time, and in that period, other factors (such as the economic and financial crises) have masked potential impacts from the EU ETS.

Additionally, the global scope of carbon pricing is increasing, and one of the EU's main competitors in the soda ash market – China – is set to introduce a national ETS next year. Depending on how that ETS is managed and implemented, a number of expected negative impacts of the EU ETS, such as carbon leakage, might be limited.

However, other countries that have not been studied in-depth in this case study (such as Turkey and India) have no clear climate change policies in place that impact the soda ash sector. For the foreseeable future, asymmetries in climate change policies will continue to persist, as will the unintended competitive impacts of those asymmetries.

## **4. Mitigation of impacts of climate change policies**

The unintended impacts of climate change mitigation policies need to be managed in order to enable the transition to a low GHG economy. Impacts can be domestic or international, and the tools to mitigate impacts can also be implemented at the domestic or international level.

### **4.1 *Domestic mitigation tools***

In the same way that the EU ETS was at the heart of the chapter on impacts of climate change mitigation policies, it is also at the centre of this chapter, which covers the mitigation and management of those impacts. The main EU tool to mitigate the economic and environmental impacts is the free allocation to limit the risks of carbon leakage.

#### **4.1.1 *Mitigation of EU ETS economic and environmental impacts***

There are several cost mitigation measures in place in the EU ETS to address costs faced by industrial producers in the EU. The most important one (the Carbon Leakage List) is analysed in depth. Other cost mitigation measures are briefly discussed.

##### **A. Carbon Leakage List**

There are a number of factors that may enable asymmetric carbon policies to result in carbon leakage. These so-called 'carbon leakage risk factors' determine whether climate policies increase the carbon leakage risk for a product or a sector on the basis of two criteria: the size of the carbon cost and the ability of the sector to pass through carbon costs to other sectors or consumers.

Sectors deemed at risk of carbon leakage are on the Carbon Leakage List, and receive free allowances at 100% of their benchmarks. Free allocation through the Carbon Leakage List acts to reduce some of the intended impacts of the EU ETS (direct costs), thereby reducing the risk of unintended impacts (production shifts, plant closures etc) materializing. If an activity fulfils any of the following three thresholds, they are added to the leakage list:

- a) Direct and indirect costs increase production costs by at least 5% of gross value added and trade intensity (calculated as the value of imports plus exports over annual turnover plus imports) is over 10%,
- b) Direct and indirect costs increase production costs by at least 30% or
- c) Trade intensity is over 30%.

There is significant ongoing debate on whether carbon leakage protection has been overly generous as nearly all manufacturing sectors are on the list. Currently the Carbon Leakage List covers approximately 95% of total industrial emissions in the EU ETS (De Bruyn et al., 2013), although the rules are set to change from 2021 onwards; but this case study focuses on the current rules.

Allocation to sectors on the list is largely determined by the product benchmarks, established in the Benchmarking Decision. The benchmarks are determined as the number of allowances received per tonne of production at the installation. However, the level of production at an installation is based on historical levels: the median production during the period from 1 January 2005 to 31 December 2008, or, where it is higher, on the median production during the period from 1 January 2009 to 31 December 2010. For the soda ash sector, this benchmark was set at 0.843 tonnes of CO<sub>2</sub>e per tonne of soda ash. Installations that are more emissions-intensive are motivated to catch up to their best-performing peers.

The soda ash sector is on Carbon Leakage List. Free allocation is made according to the following formula:

$$\text{Allocation} = \text{benchmark} \times \text{historical activity level} \times \text{carbon leakage exposure factor} \times \text{cross-sectoral correction factor}$$

Where the historical activity level (=production) is installation specific, and the carbon leakage factor is 1 for the soda ash sector. The cross-sectoral correction factor guarantees that the sum of the free allocation proposed by each member state does not exceed the EU ETS-wide cap on free allocation. The cross-sectoral correction factor determines the proportion of the proposed free allocation that is granted to each installation that is eligible to receive allocation and will decrease yearly to reach circa 82,44% in 2020.

Changes in production are currently not taken into account, unless production is scaled back to less than 50% of the historical level (when free allocation is stopped). Production increases beyond historical levels (and thus emissions increases) also fall outside the scope of the benchmark and therefore are not taken into account during free allocation of allowances. Expansion of production beyond historical levels therefore causes direct EU ETS costs, even for installations that are more

efficient than the benchmark. However, plants that increase capacity can apply for increases in allocation to adjust their free allocation to the new plant capacity.

To establish the effectiveness of this tool, we analyse the potential direct EU ETS costs with and without carbon leakage-linked free allocation (see Table 2). We assume zero free allocation to manufacturing sectors that are not on the list, which does not take the carbon leakage exposure factor for sectors not on the carbon leakage list into account. All manufacturing sectors currently receive free allowances.

*Table 2. Total additional costs with and without free allocation at benchmark level, for plants with different emissions intensities for two EUA prices, and with estimated percentages of current cash costs (approx. €150/tonne of soda ash)*

Carbon price	Carbon cost for <b>low emissions-intensive plant</b> (0.8 tonne of CO <sub>2</sub> per tonne of soda ash)	Carbon cost for <b>medium emissions-intensive plant</b> (1.15 tonnes of CO <sub>2</sub> per tonne of soda ash)	Carbon cost for <b>high emissions-intensive plant</b> (1.4 tonnes of CO <sub>2</sub> per tonne of soda ash)
<b><u>With free allocation at benchmark level (0.843 EUAs per tonne of soda ash)</u></b>			
€8 per EUA (or 1 tonne of CO <sub>2</sub> )	<b>€-0.24</b> Approx. <b>0.2%</b> of production costs	<b>€2.56</b> Approx. <b>2%</b> of production costs	<b>€4.56</b> Approx. <b>3%</b> of production costs
€30 per EUA (or 1 tonne of CO <sub>2</sub> )	<b>€-1.19</b> Approx. <b>1%</b> of production costs	<b>€9.31</b> Approx. <b>6%</b> of production costs	<b>€16.81</b> Approx. <b>11%</b> of production costs
<b><u>Without free allocation at benchmark level</u></b>			
€8 per EUA (or 1 tonne of CO <sub>2</sub> )	<b>€6.5</b> Approx. <b>4%</b> of production costs	<b>€9.3</b> Approx. <b>6%</b> of production costs	<b>€11.3</b> Approx. <b>8%</b> of production costs
€30 per EUA (or 1 tonne of CO <sub>2</sub> )	<b>€24.1</b> Approx. <b>16%</b> of production costs	<b>€34.6</b> Approx. <b>23%</b> of production costs	<b>€42.1</b> Approx. <b>28%</b> of production costs

Source: Author's own calculations.

Comparing the situations with and without free allocation shows that, as expected, the EU ETS direct costs per tonne are significantly higher without free allocation. With a EUA price of €8 per tonne, production costs are €6.7 higher for each type of plant. With a EUA price of €30 per tonne, production costs are €25.3 higher. It is also clear that all plants are witnessing a significant increase in production costs; from 4% (in the best circumstances) to 28% (in the worst circumstances) without free allocation. The direct cost of the EU ETS is reduced by more than 60% for high emission intensive soda ash plants.

However, in the real world the soda ash sector has received significant free allocation. The lack of flexibility in the supply of free allocation, which is based on historical activity levels, has shielded the soda ash sector from direct EU ETS costs. In the longer term we cannot expect this effect to continue as demand picks up. Also, the expectation is that free allocation will not remain at current levels ad infinitum. The total amount of free allocation decreases every year: in 2015 it is set to be 1.79%

lower than in 2014 (European Commission, 2013) through the continued impact of the cross-sectoral correction factor, which cuts free allocation to all installations based on a pre-determined factor derived from the decreasing overall cap in the ETS. This will lead to increased upwards pressure on direct costs in the long term.

#### B. Other cost mitigation measures

Besides the Carbon Leakage List, there are two main tools that are or have been used in the EU: a) international offsets and b) state aid to compensate indirect costs for electricity-intensive industries.

International offsets can be surrendered instead of EUAs, and are in general far cheaper. However their use has been subjected to conditions starting in 2013, and from 2020 onwards they will no longer be accepted. However, international offsets have not been surrendered by any of the EU soda ash plants, most likely because soda ash entered the EU ETS as conditions for the use international offsets were being implemented.

State aid to compensate indirect costs for electricity-intensive industries can be given by EU member states after they receive approval for their state aid scheme from the European Commission. This state aid aims to compensate electricity-intensive industries (such as the aluminium sector) for the indirect costs that have been passed through to them by power producers. In this manner it reduces the intended indirect costs for industries in order to reduce the risk for unintended impacts. Details on sums granted to specific plants and industries is not public, but it is safe to assume that this scheme is not of particular relevance for the soda ash sector as it is not an electricity-intensive sector.

#### C. Conclusion

Free allocation through the Carbon Leakage List in the EU ETS is the main cost-mitigating measure, and strongly mitigates the direct costs for the soda ash sector, thereby reducing the risk of unintended impacts materializing, such as employment losses and changes in production and trade trends. This reduction of direct costs also means that lower indirect costs are passed on to downstream sectors, further mitigating downstream impacts of the EU ETS that were discussed under chapter 3.

##### *4.1.2 Mitigation of EU ETS social impacts*

Social impacts – most notably job losses – that the EU ETS might cause are not dealt with at the EU ETS or indeed the EU level. There is no international safety net in place to mitigate the unintended social impacts of the EU ETS.

EU member states have social security and safety nets in place. Owners of plants that are being closed are frequently involved in the implementation and operation of mitigation measures. In case of large job losses (for example, because of the closure of a major car factory), they can receive support from governments to help mitigate the effects on workers (Belga, 2013).

Mitigation measures can include retraining programmes, early retirement, unemployment benefits and support programmes to help switch to other jobs, as illustrated by the recent closure of two soda ash plants. The 2014 closure of the Povia plant in Portugal affected 450 workers, and the operator (Solvay) sought to mitigate the impacts by helping employees to relocate to fill job openings in other Solvay facilities throughout Europe (Solvay, 2013). The Winnington plant in the UK was also closed in 2014, and the number of compulsory redundancies was limited to 75 (out of a total of 220

employees) through redeployment and voluntary redundancies. Tata Chemicals Europe, the operator of the plant, provided packages and outplacement programmes (Taylor, 2013).

## **4.2 International cooperative approaches**

Tools to measure and mitigate the international impacts of climate change policies and projects are currently lacking.

At the UNFCCC level, there is a commitment by Parties to consider the adverse impacts of climate change policies and projects (also known as 'response measures'), especially for developing countries. The Kyoto Protocol includes a promise to strive to minimise the adverse economic, social and environmental impacts of climate change mitigation policies on other Parties, especially developing countries. However, there has been significant debate on how to implement this.

In response to the lack of information on response measures, a forum to discuss response measures was established at COP17 in Durban. This forum is a joint agenda programme of both the subsidiary bodies, and has the specific goal of improving the understanding of the negative impacts of climate change mitigation policies and projects. However, the progress achieved through this forum has been limited. Currently there is a discussion ongoing on the continuation of the forum. While Parties have expressed support for the continuation, the forum is currently in a grey zone. Progress on this topic is expected during COP21 in Paris.

## **4.3 Conclusion on mitigation of impacts**

The lack of clear economic impacts up to now can be, at least partially, attributed to the effectiveness of free allocation linked to the Carbon Leakage List. As a mitigation measure it has been effective at shielding the domestic soda ash sector from direct EU ETS costs, and therefore limits the risk of unintended impacts materializing and reduces the cost that is passed through to downstream sectors, both in the EU and third countries. Its effectiveness may change as the cross-sectoral correction factor continues to decrease over time.

However, it may also be that the inclusion of the soda ash sector in the EU ETS is too recent to discern strong unintended impacts that have not been mitigated. Energy prices are currently the most important raw material cost, but that could change if EUA prices increase to levels closer to €30 per EUA (as expected in EU impact assessments (European Commission, 2010b)).

Additional climate-related costs could be borne by the EU soda ash sector, if international competitors face similar costs.

One of the main issue that this case study identifies is the lack of clear and public data to identify, measure and mitigate the negative impacts of climate change policies, both domestically and internationally.

While the EU does carry out impact assessments up-front, there are no follow-up exercises that check whether the expected impacts actually materialised, and whether there were any unexpected impacts. There is also a lack of tested methodologies to identify impacts and mitigation measures, especially beyond the implementing jurisdiction, for instance in developing countries.

## 5. Conclusion

Currently there are significant asymmetrical climate change policies implemented for the global soda ash sector. EU producers face significant climate change measures, Chinese producers may from 2017 onwards, but no climate change measures are in the pipeline for US producers. This changes the competitive landscape. The impacts of climate change mitigation policies constitute only one of many factors affecting competitiveness: regional differences in the cost of energy and raw materials are far more important.

The EU ETS has both intended and unintended, positive and negative impacts. These impacts are not only on emissions (their intended target area), but also in other facets of public policy – economic, social and environmental.

On the positive side, the EU ETS incentivizes continued low-GHG innovation, which could be a boon to the EU soda ash sector if carbon pricing policies continue to spread globally.

On the economic side the impact of the EU ETS is currently low. The most GHG efficient producers are far less impacted than their less carbon efficient peers, and can even benefit from the EU ETS. The impacts have been significantly mitigated by the main mitigation measure: free allocation.

There are also potential unintended impacts, difficult to quantify, for soda ash users in third countries: EU ETS costs could be passed through to them through increases in the price of soda ash internationally. This has the potential to impact the cost of glass, and some consumer products, in developing countries. While these international impacts are difficult to quantify, given the level of EU allowance prices, it is unlikely that they have had a significant impact at this stage.

The EU ETS' unintended impacts on trade, investment and production trends, cannot currently be segregated. Macroeconomic events, such as the economic and financial crises are deemed to have had a far greater impact. The impacts on employment have, so far, been limited. The past decade a number of soda ash plants in the EU have closed down, but energy prices are deemed a far greater factor in this than EU ETS costs.

However, the cost that emerge from the EU ETS have the potential to become substantial for soda ash producers, and the chain that includes users of soda ash in jurisdictions outside the EU, including developing countries. Three main factors will determine the EU ETS costs for the soda ash sector in the future: 1) the choice of fuel to generate heat 2) the evolution of the price of EUAs and 3) the continued reduction in freely allocated EUAs, which is the most important flanking measure to accompany carbon pricing.

While the domestic social impacts of the EU ETS can be addressed through safety nets and flanking measures (such as retraining schemes) that exist in the EU's Member States, there is a lack of recognition and management of potential international impacts. The international impacts of the EU ETS are currently not the focus of policy makers, and are therefore not identified or measured in a systematic manner. Ultimately it is impossible to manage the negative unintended impacts of climate-related policies if those impacts are not known.

Beyond the lessons learned specific to the soda ash case, the analysis here supports the notion that any climate change policies should be carefully assessed for their broader sustainable development impacts, domestically and internationally, both in their initial elaboration, as well as on an on-going basis.

## **Bibliography**

- American Natural Soda Ash Corporations (2010), "Statement of ANSAC on the U.S. – China Trade Relationship: Finding a New Path Forward", Statement before the Committee on Finance United States Senate, June.
- Bel. G. and S. Joseph (2014), "Industrial Emissions Abatement: Untangling the Impact of the EU ETS and the Economic Crisis", Working Paper 201/22 for Research Institute of Applied Economics ([http://www.ub.edu/irea/working\\_papers/2014/201422.pdf](http://www.ub.edu/irea/working_papers/2014/201422.pdf)).
- Belga (2013), "Outplacement gestart bij toeleveranciers Ford Genk [Outplacement started for suppliers Ford Genk]", *De Morgen*, 27 June.
- Carbon Pulse (2015a), "Guangdong to add six sectors in carbon market expansion" (<http://carbon-pulse.com/china-to-confirm-national-ets-delay-pilots-set-to-run-a-year-longer/>).
- Carbon Pulse (2015b), "China confirms national ETS delay, pledges \$3.1 bln in climate finance" (<http://carbon-pulse.com/guangdong-to-add-six-sectors-in-carbon-market-expansion/>).
- CEFIC (2004), "IPPC BAT Reference Document, large volume solid inorganic chemicals family – Process BREF for soda ash", prepared by ESAPA ([www.cefic.org/Documents/Industry%20sectors/ESAPA\\_Soda\\_Ash\\_Process\\_BREF3.pdf](http://www.cefic.org/Documents/Industry%20sectors/ESAPA_Soda_Ash_Process_BREF3.pdf))
- De Bruyn S. et al. (2010), "Does the energy intensive industry obtain windfall profits through the EU ETS?", CE Delft ([www.ce.nl](http://www.ce.nl)).
- De Bruyn, S., D. Nelissen and M. Koppman (2013), "Carbon leakage and the future of the EU ETS market. Impact of recent development in the EU ETS on the list of sectors deemed to be exposed to carbon leakage", Delft, CE Delft, April 2013.
- Ecofys, Fraunhofer Institute for Systems and Innovation Research and Öko-institut (2009a), "Methodology for the free allocation of emission allowances in the EU ETS post 2012 – Sector report for the glass industry", study in order of the European Commission.
- Ecofys, Fraunhofer Institute for Systems and Innovation Research and Öko-institut (2009b), "Methodology for the free allocation of emission allowances in the EU ETS post 2012 – Sector report for the chemicals industry", study in order of the European Commission.
- Ecorys, Tehnologisk Institut, Cambridge Economics, IFO and DEA Consult (2008), "FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector", client: DG Enterprise and Industry.
- Egenhofer C., L. Schrefler, C. Rizos, A. Renda, A. Marcu, F. Genoese, J. Wieczorkiewicz, S. Roth, F. Infelise, G. Luchetta, L. Colantoni, W. Stoefs, J. Timini, D. Simonelli (2014a) "Study on composition and drivers of energy prices and costs in energy intensive industries: the case of ceramics, flat glass and chemical industries", contracted by the European Commission under a Framework Contract.
- Egenhofer C., L. Schrefler, C. Rizos, A. Renda, A. Marcu, F. Genoese, J. Wieczorkiewicz, S. Roth, F. Infelise, G. Luchetta, L. Colantoni, W. Stoefs, J. Timini, D. Simonelli (2014b) "Study on composition and drivers of energy prices and costs in energy intensive industries: the case of ceramics, flat glass and chemical industries – Cross-sectoral Analysis", contracted by the European Commission under a Framework Contract.



- Environmental Protection Agency (1983), "Enforcement of Prevention of Significant Deterioration Requirements Under the Clean Air Act", December ([www2.epa.gov/sites/production/files/documents/prev-deter-rpt.pdf](http://www2.epa.gov/sites/production/files/documents/prev-deter-rpt.pdf))
- Environmental Protection Agency (2011), "PDS and Title V Permitting Guidance for Greenhouse Gases", March ([www3.epa.gov/nsr/ghgdocs/ghgpermittingguidance.pdf](http://www3.epa.gov/nsr/ghgdocs/ghgpermittingguidance.pdf))
- Environmental Protection Agency (2015), "Clean Power Plan for Existing Power Plants", August (<http://www2.epa.gov/sites/production/files/2015-08/documents/cpp-final-rule.pdf>)
- European Soda Ash Producers Association (2015), "ESAPA – European Soda Ash Producers Association", information presentation on ESAPA.
- European Commission (2003), Directive 2003/87/EC of the European Parliament And Of The Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, OJ L 275, 25.10.2003.
- European Commission (2007), "Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals – Solids and Others Industry", August.
- European Commission (2008), "Commission Staff Working Document Annex to the Impact Assessment – Document accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020, Proposals for: Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system, Decision of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020, Directive of the European Parliament and of the Council on the promotion of use of renewable energy sources ([http://ec.europa.eu/smart-regulation/impact/ia\\_carried\\_out/docs/ia\\_2008/climate\\_package\\_ia\\_annex.pdf](http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2008/climate_package_ia_annex.pdf))
- European Commission (2009a), Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009, amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community, *Official Journal of the European Union* L 140/16, 5.6.2009.
- European Commission (2009b), Directive 2009/28/EC of the European Parliament And Of The Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, *Official Journal of the European Union* L 140/16, 5.6.2009.
- European Commission (2009c), Commission Decision of 24 December 2009 determining, pursuant to Directive 2003/87/EC a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage (2010/2/EU).
- European Commission (2010a), Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (<http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0075&from=EN>).

European Commission (2010b), Commission Staff Working Document Impact Assessment: Accompanying document to the Commission Decision on determining transitional Union-wide rules for harmonised free allocation pursuant to Article 10a of Directive 2003/87/EC.

European Commission (2011), Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (2001/278/EU).

European Commission (2012), Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and the Council.

European Commission (2013), Commission Decision of 5 September 2013, concerning national implementation measures for the transitional free allocation of greenhouse gas emission allowances in accordance with Article 11(3) of Directive 2003/87/EC of European Parliament and of the Council (2013/448/EU).

European Commission (2014a), Commission Staff Working Document Impact Assessment: Accompanying document to the Commission Decision determining, pursuant to Directive 2003/87/EC of the European Parliament and the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage for the period 2015-2019 ([http://ec.europa.eu/clima/policies/ets/cap/leakage/docs/20140502\\_impact\\_assessment\\_en.pdf](http://ec.europa.eu/clima/policies/ets/cap/leakage/docs/20140502_impact_assessment_en.pdf)).

European Commission (2014b), Commission Staff Working Document Impact Assessment, Accompanying the document Proposal for a Decision of the European Parliament and of the Council concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC, Brussels, 22 January.

European Commission (2015a), Commission Staff Working Document Impact Assessment, Accompanying the document Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments {COM(2015) 337 final}, Brussels, 15 July.

European Commission (2015b), European Union Transaction Log, consulted in Summer and Autumn 2015 ([ec.europa.eu/environment/ets/](http://ec.europa.eu/environment/ets/)).

European Commission (2015c), Proposal for a Directive amending Directive 2003/87/EC to enhance cost-effective emissions reductions and low-carbon investments.

European Energy Exchange (2015), data on EUA spot prices for delivery in December of the same year, consulted in Summer 2015, ([www.eex.com/en/market-data/emission-allowances/spot-market/european-emission-allowances](http://www.eex.com/en/market-data/emission-allowances/spot-market/european-emission-allowances))

GDP-Suez (2015), “market review”, first week of May.

Grahl, C. (2002), “Saving Energy with Raw Materials”, *Ceramic Industry*, July.

IHS (2015), sector and national level data on production, production cost components, transportation costs and capacity.

- International Carbon Action Partnership (2015a), “China to cap emissions from six sectors, ETS to launch 2016” (<https://icapcarbonaction.com/news/news-archive/268-china-to-cap-emissions-from-six-sectors-ets-to-launch-2016>)
- International Carbon Action Partnership (2015b), “China”, icap ETS detailed information sheet on China ETS (<https://icapcarbonaction.com/news/news-archive/268-china-to-cap-emissions-from-six-sectors-ets-to-launch-2016>)
- International Carbon Action Partnership (2015c), ETS Map, icap ETS map with links to detailed information sheets on seven Chinese Pilot ETS (<https://icapcarbonaction.com/ets-map>)
- Mangino, J. (2010), “Prevention of Significant Deterioration and Title V Greenhouse Gas Tailored Rule”, presentation ([www.epa.gov/apti/video/TailoringRule/tailoring.pdf](http://www.epa.gov/apti/video/TailoringRule/tailoring.pdf))
- Marcu A., C. Egenhofer, S. Roth and W. Stoefs (2013), “Carbon Leakage: An overview”.
- Marcu A., C. Egenhofer, S. Roth and W. Stoefs (2014), “Carbon Leakage: Options for the EU”.
- Pilkington, (2010), Pilkington and the Flat Glass Industry 2010, NSG Group.
- Renda, A., J. Pelkmans, C. Egenhofer, A. Marcu, L. Schrefler, G. Luchetta, F. Simonelli, F. Genoese, D. Valiante, F. Mustilli, L. Colantoni, F. Infelise, W. Stoefs, J. Teusch, J. Timini, J. Wieczorkiewicz, R. Zavatta, E. Giannotti and G.M. Stecchi (2013a), “Assessment of cumulative cost impact for the steel and the aluminium industry – final report Aluminium” (<http://ec.europa.eu/smart-regulation/evaluation/search/download.do?documentId=9438143>).
- Renda, A., J. Pelkmans, C. Egenhofer, A. Marcu, L. Schrefler, G. Luchetta, F. Simonelli, F. Genoese, D. Valiante, F. Mustilli, L. Colantoni, F. Infelise, W. Stoefs, J. Teusch, J. Timini, J. Wieczorkiewicz, R. Zavatta, E. Giannotti and G.M. Stecchi (2013b), “Assessment of cumulative cost impact for the steel and the aluminium industry – final report Steel” ([http://bookshop.europa.eu/en/assessment-of-cumulative-cost-impact-for-the-steel-industry-pbNB0413083/downloads/NB-04-13-083-EN-N/NB0413083ENN\\_002.pdf?FileName=NB0413083ENN\\_002.pdf&SKU=NB0413083ENN\\_PDF&CatalogueNumber=NB-04-13-083-EN-N](http://bookshop.europa.eu/en/assessment-of-cumulative-cost-impact-for-the-steel-industry-pbNB0413083/downloads/NB-04-13-083-EN-N/NB0413083ENN_002.pdf?FileName=NB0413083ENN_002.pdf&SKU=NB0413083ENN_PDF&CatalogueNumber=NB-04-13-083-EN-N)).
- Sevas educational society (2007), “Various chemical processes production of soda ash” ([www.sbioinformatics.com/design\\_thesis/Soda\\_ash/Soda-2520ash\\_Methods-2520of-2520Production.pdf](http://www.sbioinformatics.com/design_thesis/Soda_ash/Soda-2520ash_Methods-2520of-2520Production.pdf))
- Solvay (2013), “Solvay to reinforce its global leadership in soda ash”, press release on June, Brussels ([www.solvay.com/en/media/press\\_releases/20130606-soda-ash.html](http://www.solvay.com/en/media/press_releases/20130606-soda-ash.html))
- Taylor, M. (2013), “Tata confirms New Year Winnington Closures”, Northwich Guardian, 11 December ([www.northwichguardian.co.uk/news/10867159.Tata\\_confirms\\_New\\_Year\\_Winnington\\_closures/](http://www.northwichguardian.co.uk/news/10867159.Tata_confirms_New_Year_Winnington_closures/)).
- Thieme, C. (2012), “Sodium Carbonates”, Ullmann’s Encyclopedia of Industrial Chemistry, Solingen.
- United States Geological Survey (2015), “Soda Ash – Statistics and Information”, USGS soda ash factsheet ([http://minerals.usgs.gov/minerals/pubs/commodity/soda\\_ash/](http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/))
- Vivid Economics and Ecofys (2014), “Carbon Leakage Prospects Under Phase III EU ETS”.