

Determining Embedded emissions under the CBAM method for two different fertiliser production pathways during the transitional period

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This guidance document was reviewed by TÜV Rheinland Cert GmbH to strengthen its credibility, reliability, and completeness. TÜV Rheinland is a leading international provider of independent testing, inspection, certification, training, and sustainability services, supporting organizations worldwide in ensuring quality, safety, and compliance with global regulatory requirements.

The review process included a detailed evaluation of formulas for calculating both direct and indirect emissions, ensuring consistency with the methodologies prescribed in Commission Implementing Regulation (EU) 2023/1773 and Regulation (EU) 2023/956. These formulas were specifically applied to two production pathways for mixed fertilizers to validate their correctness, robustness, and applicability across different production scenarios. In addition, the methodology for determining the number of CBAM certificates was critically reviewed to confirm accuracy, transparency, and suitability for CBAM price determination. The review also examined the overall clarity and completeness of the toolkit to ensure it can serve as a practical reference for stakeholders involved in emissions reporting for fertilizers under the CBAM mechanism.

At the end of the review, it was concluded that the developed toolkit comprehensively addresses the regulatory requirements and provides a sound basis for emission calculation and certificate determination under CBAM.

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1 Introduction

1.1 What is the purpose of the document?

The aim of this document is to provide an overview of how emissions can be determined under the European Union's Carbon Border Adjustment Mechanism (CBAM) transitional phase for two different hydrogen-based mixed fertilizers examples by applying the CBAM methodology for emissions accounting. The first production pathway uses grey hydrogen-based ammonia to produce mixed fertiliser, and the second one uses certified renewable hydrogen (RFNBO) for ammonia production and an emission factor of 0 for all indirect emissions involved in the production process, assuming electricity comes from renewable sources. For this comparison the fertilizer example provided by the European Commission as part of the [CBAM guidance document for installations outside the EU has been taken as reference](#). This should serve as a learning exercise in preparation of the definitive period where a new methodology will be adopted. The new methodology is expected to be largely based on the methodology used during the transition phase. The CBAM Regulation provides for a series of implementing and delegated acts to be adopted which will clarify and harmonise key technical aspects of the CBAM, such as the calculation of embedded emissions (Article 7), adjustments of the CBAM obligation taking into account the carbon price effectively paid in the country of origin of the product (Article 9) and reflecting the EU ETS free allocation between 2026 and 2034 (Article 31). At the time of drafting this document, the European Commission was conducting several public consultations on these and other important aspects for a review of the CBAM.

The document begins with a general overview of the CBAM mechanism, including specific considerations for the fertilizer sector, followed by the presentation of calculation formulas and their application to the two examples mentioned above.

1.2 What are CBAM objectives

The European Union Carbon Border Adjustment Mechanism (CBAM) aims to support the EU goal of achieving climate neutrality by 2050 and will work alongside other measures in the "Fit for 55" package.¹ CBAM main goals include carbon leakage prevention, to complement, and reinforce the EU emissions trading system (EU-ETS), and to contribute to global decarbonization. The EU-CBAM also seeks to apply an equivalent carbon price for emissions of specific goods under CBAM scope imported into the EU equivalent to the carbon price paid by EU producers under the EU-ETS.

Carbon leakage occurs when carbon-intensive industries in the EU relocate their production to third countries with less stringent climate policies, thus undermining global decarbonization efforts. Existing measures to prevent carbon leakage, particularly the allocation of free emission allowances under the EU Emissions Trading System already exist. CBAM aims to gradually phase out the EU-ETS free allowances for CBAM covered sectors, among others, to ensure that there is no double protection for EU producers.

CBAM will start addressing a specific number of products within six main sectors whose production is carbon intense, and which are more prone to carbon leakage. These sectors are aluminium, iron and steel, cement, fertiliser, electricity, and hydrogen.

1.3 Implementation of CBAM

The implementation of the CBAM will unfold along two main phases, which have different characteristics and requirements as explained below:

Transitional phase (October 2023 – December 2025): This phase is deemed as a learning phase for all parties involved. During this phase CBAM will focus on monitoring and reporting, meaning that no certificate purchase will be required. CBAM quarterly reports outlining the quantities of goods imported under CBAM scope, the embedded emissions (both direct and

¹ European Commission - Delivering the European Green Deal ([Link](#))

indirect) associated with these goods imported, as well as any carbon pricing due should be reported under the CBAM transitional registry.

From 1 January 2025 onwards, a new portal section of the CBAM transitional Registry will allow installation operators outside the EU to upload and share their installations and emissions data with reporting declarants. The registration for installation operators is open from 1 January 2025². From the same date onwards, CBAM declarants will be able to apply for the “authorized CBAM declarant” status, via the CBAM Registry. In this case, the application will be processed by the National Competent authority of the EU Member State where they are established. It is important to mention that from 1 January 2026 (definitive regime) this status will become mandatory for the import of CBAM goods in the EU customs territory.³

As per the Omnibus legislative package, key elements of CBAM design⁴ have been simplified without compromising its climate goals. Among other simplification measures, a new “de-minimis” threshold has been introduced and set at a level of 50 tonnes of imported goods per importer per year. During 2025 the European Commission will develop an extensive review of some of CBAM’s main design elements. For further information on the state of play of the revision process please see: [PtX Policy Developments summer update 2025](#).

During 2025 the European Commission will develop an extensive review of some of CBAM’s main design elements, which might include an emission and a product scope extension.

Post transitional phase (2026 to 2034): from 1st January 2026, only authorized declarants will be able to import CBAM goods into the EU. During the definitive phase, authorized declarants will have to buy and surrender CBAM certificates, corresponding to the embedded emissions in the imported goods. The price of the CBAM certificates will be based on the average weekly price of the ETS auctions.

2 Considerations for fertilisers

The CBAM mechanism includes specific considerations for the fertilizers sector. Some of these specifications are explained in the following section in the form of Q&A. For further guidance please visit the [European Commission Guidance Document for Installations Operators, sections 5.5 Fertilizers Sector and 7.3](#).

-What are the CN codes⁵ for fertilisers under CBAM scope?

Please refer to Annex I.

-What are complex and simple goods in the context of CBAM?

Simple goods are goods with zero embedded emissions associated with the input materials used for production of CBAM goods. In the case of fertilisers, ammonia is the only one that could be classified as a simple good, however when hydrogen from other production routes is added to the process and produced separately, it shall be treated as a precursor and therefore Ammonia would be considered as a complex good.

Complex goods means that input material/raw materials/precursors to produce the complex good, are themselves under the scope of CBAM. Relevant precursors refer to those raw materials used in the production of complex CBAM goods that are CBAM goods themselves⁶.

Complex fertiliser goods embed the emissions from precursor goods that fall within the scope of CBAM.

² European Union External Action - CBAM Registry access is open for non-EU installation operators ([Link](#)).

³ European Commission – Carbon Border Adjustment Mechanism ([Link](#)).

⁴ At the time of drafting this document, the text still has to be officially endorsed by Council. It will enter into force three days after publication in the EU Official Journal.

⁵ CN stands for Combined Nomenclature and is a tool for classifying goods, set up to meet the requirements both Common Customs Tariff and of the EU’s external trade statistics. - European Commission -What is the Common Customs Tariff? ([Link](#)). As CBAM deals with aggregated goods, CN codes with four digits (e.g. 3102) include all other goods under that category (six- or eight-digit CN codes, e.g. 3102 21 00).

⁶ Example of a complex good is Portland Cement, since it uses cement clinker as a precursor, which is under the scope of CBAM itself. Q62 - European Commission – Questions & Answers ([Link](#)).

-Which precursors in fertiliser production are relevant within the scope of CBAM?

Aggregated good category / Production route	Relevant precursor
Ammonia Haber Bosch with steam reforming Haber Bosch with gasification	Hydrogen, if separately produced for use in the process
Nitric Acid	Ammonia (as 100% ammonia).
Urea	Ammonia (as 100% ammonia)
Mixed fertilizer	If used in the process: ammonia (as 100% ammonia), nitric acid (as 100% nitric acid), urea, mixed fertilizers (salts containing ammonium or nitrate).

-What are the GHG emissions under scope?

The main greenhouse gas under the scope is carbon dioxide. In the case of certain fertiliser goods, Nitrous Oxide (N₂O) is also considered. (N₂O) emissions will be expressed in terms of CO₂ equivalent for the calculation of embedded emissions. The nitrous oxide emissions generated are frequently those that are emitted during the catalytic oxidation of ammonia and/or from abatement units, mainly during the production of nitric acid as an ammonia byproduct.

-What is the emission scope during the transitional period for fertilizer goods?

During the transitional period, the emissions scope includes direct⁷ and indirect⁸ emissions.

-What is the emission scope during the definitive period for fertilizer goods?

During the definitive period, the emissions scope will still include both direct and indirect emissions. It should be noted that for the hydrogen used for Ammonia production, indirect emissions are for now not in CBAM scope in the definitive period and therefore should not be taken into account.

-What are the main elements that will define the monetary value of the CBAM financial adjustments during the definitive phase?

- Quantity of imported fertilizers in tons,
- Direct and indirect emissions of fertilizer production⁹
- Carbon price effectively paid in the country of production.¹⁰
- % of CBAM phase in until 2034 as CBAM will be progressively introduced.
- Price of the EU-ETS allowances. (Weekly average of the closing prices on the auction platform)
- CBAM benchmarks (to be defined by the European Commission)

-Who will be responsible for reporting and for the financial obligations during the definitive period?

The responsibility lies with the authorized reporting declarant. The authorized reporting declarant can be either: The importer: who can act on his own or use a direct representative (if the importer is located in the EU). Or the indirect customs representative if the importer is based outside the EU.

⁷ Direct emissions cover the emissions generated during the production processes of CBAM goods, including from the production of heating and cooling, irrespective of the location of the production of the heating and cooling. This means that when the production of heating and cooling takes place outside the installations, the resulting emissions are counted as direct emissions. Q63 - European Commission – Questions & Answers ([Link](#))

⁸ Indirect emissions cover the production of electricity that is consumed during the production of CBAM goods. Q63 - European Commission – Questions & Answers ([Link](#))

⁹ During the definitive period will be only direct emissions, subject to review. Q39 - European Commission – Questions & Answers ([Link](#))

¹⁰ Carbon price effectively paid stands for the monetary amount paid in a third country, under a carbon emissions reduction scheme, in the form of a tax, levy or fee or in the form of allowance under a greenhouse gas emissions trading system (...) Q134 - European Commission – Questions & Answers ([Link](#))

-Who will be responsible for the monitoring of emissions at the installation level?

Although reporting declarants will be responsible for reporting and financial obligations under CBAM, in some cases, these will rely on information on emissions provided by the exporting installation in a third country. Operators in third countries may monitor emissions according to the CBAM methodology to facilitate the compliance obligations of the reporting declarant.

-Are installations in third countries obliged to use the CBAM method for emissions monitoring during the definitive period?

No, CBAM obligations apply to the reporting declarant. As per the Omnibus legislative package¹¹ and for goods other than electricity as a CBAM good, in the definitive period, reporting declarants can determine embedded emissions on the basis of either default values with a mark-up or actual values from the third country installation, calculated according to the CBAM methodology and verified by accredited verifiers. Currently [default values for the transitional period](#) apply only until the end of the transitional period and are based on world averages at the 4, 6 and 8 digit CN code level. For the definitive period a new set of more specific default values with a mark-up will apply.

-How will the reliability of data provided be ensured?

The European Commission, and EU member states will continuously monitor reported emissions and other information provided. During the definitive period, a verification system will be put in place and an accredited verifier will prepare a verification report. In case of non-compliance penalties could be imposed on the reporting declarant. As per the adopted Omnibus legislative package verification of embedded emissions provided by means of default values will not be needed.¹²

-What is the CBAM Transitional Registry?

The CBAM Transitional Registry is a standardized and secure electronic database containing common data elements for reporting in the transitional period, providing for access, case handling and confidentiality.¹³

Table 1 Fertiliser key information under CBAM during the transitional phase.

	Type of good	CN Code	Greenhouse gas	Emissions
Ammonia	Simple good	2814	Carbon dioxide	Direct & indirect
Nitric acid	Complex good	2808 00 00	Carbon dioxide and nitrous oxide	Direct & indirect
Urea	Complex good	3102 10	Carbon dioxide	Direct & indirect
Mixed fertilisers	Complex good	2834 21 00 3102 3105	Carbon dioxide and nitrous oxide	Direct & indirect

3 How to determine Direct and Indirect Emission

The CBAM Regulation builds on the principle of applying a top-down approach to calculating embedded emissions, starting from the installation level, and splitting those emissions such that they are attributed to different production processes (for

¹¹ 11 At the time of drafting this document, the text still has to be officially endorsed by Council. It will enter into force three days after publication in the EU Official Journal.

¹² 12 At the time of drafting this document, the text still has to be officially endorsed by Council. It will enter into force three days after publication in the EU Official Journal.

¹³ Q49 - European Commission – Questions & Answers ([Link](#))

which the system boundaries shall be defined), and thereafter to products, with further embedded emissions added for precursor materials.

3.1 Monitoring approaches for direct emissions at the installation level during the transitional phase

For the performance of monitoring in accordance with the CBAM methodology, it is necessary to monitor direct emissions at the installation level. Direct emissions cover the emissions generated during the production processes of CBAM goods, including from the production of heating and cooling, irrespective of the location of the production of the heating and cooling. This means that when the production of heating and cooling takes place outside the installations, the resulting emissions are counted as direct emissions.¹⁴

There are different methods available for calculating direct emissions. One of them, which is used in the examples provided in the following sections, is the calculation-based methodology. This method primarily relies on estimates and models and often uses emission factors to compute results. Another available method is the measurement-based methodology, which involves using data collected through sensors or monitoring devices to determine emissions. More detailed information about each methodology is provided in Table 2

Table 2 Methods for the calculation of direct emissions

Calculation-based methodology		Measurement-based methodology
Standard method	Mass balance	Continuous emissions monitoring systems
-requires the quantity of all the fuels and input material -requires calculation factors such as net calorific value (NCV) and emission factor (EF)	determine carbon quantities of all fuels and input materials determine carbon quantities of output materials.	-continuous measurement of GHG concentration directly in the stack
	Usually relevant when carbon remains on the product	Required for nitrous oxide emissions

In addition to the standard method, an example of an alternative approach based on the mass balance method has been outlined in Annex III. The application of the mass balance method must be carried out in accordance with Section B.3.2 of Annex III of Implementing Regulation (EU) 2023/1773, which outlines the principles and conditions of this method to determine direct emissions in production processes.

3.2 Attribution of direct emissions

Explanation of the formula to be used for the calculation of direct emissions and a glossary explaining each of the terms that are part of the formula are given below. Further information about the attribution of Direct emissions at installation level can be found in

Annexure II.

$$AttrEm_{dir} = DirEm^* + Em_{H,import} - Em_{H,export} + WG_{corr,import} - WG_{corr,export} - Em_{el,prod}$$

¹⁴ Q63 - European Commission – Questions & Answers ([Link](#))

Table 3 Glossary of terms for attribution of direct emissions

$AttrEm_{dir}$	attributed direct emission of the production process over the whole reporting period (tCO _{2e})
$DirEm^*$	are the directly attributable emissions from the production process determined for the reporting period
$Em_{H,imp}$	are the emissions equivalent to the quantity of measurable heat imported to the production process
$Em_{H,exp}$	are the emissions equivalent to the quantity of measurable heat exported from the production process
$WG_{corr,imp}$	are the attributed direct emissions of a production process consuming waste gases imported from other production processes, corrected
$WG_{corr,exp}$	are the emissions equivalent to the quantity of waste gases exported from the production process, determined for the reporting period using the rules provided in Section B of Annex III to the Implementing Regulation.
$Em_{el,prod}$	are the emissions equivalent to the quantity of electricity produced within the boundaries of the production process, determined for the reporting period using the rules provided in Section D of Annex III to the Implementing Regulation.

Source: Guidance document on CBAM implementation for installation operators outside the EU – [Link](#)

Additional formulas required for the calculation of $Em_{H,imp}$, $WG_{corr,imp}$, and $WG_{corr,exp}$ have been provided in Annex II for further reference.

In the context of fertilizer production, the key contributors to attributable direct emissions are the core direct emissions ($DirEm^*$) and, where applicable, emissions from on-site electricity production ($Em_{el,prod}$). Other terms in the formula adjust for interactions with external systems, such as import and export of heat and exchange of waste gases. For instance, if a fertilizer plant imports measurable heat (e.g., steam) from a nearby facility, the associated emissions $Em_{H,imp}$ is added to its total, while emissions from heat exported to other processes $Em_{H,exp}$ are subtracted. Similarly, if the plant uses waste gases from another facility as input, it must account for the emissions tied to those gases via $WG_{corr,imp}$ and if it exports waste gases for reuse elsewhere, those emissions are deducted through $WG_{corr,exp}$.

Combustion emissions¹⁵

The combustion emissions shall be calculated using the standard method as follows:

$$Em_i = AD_i \times EF_i \times OF_i$$

$$AD_i = FQ_i \times NCV_i$$

$$OF = 1 - \frac{C_{ash}}{C_{total}}$$

The conservative assumption that $OF = 1$ may always be used to reduce monitoring efforts.

Table 4 Glossary of terms for combustion emissions standard method

Em_i	Are the emissions [t CO ₂] caused by fuel i
EF_i	is the emission factor [t CO ₂ /TJ] of fuel i
AD_i	is the activity data [TJ] of fuel i
FQ_i	is the fuel quantity consumed [t or m ³] of fuel i
NCV_i	is the net calorific value (lower heating value) [TJ/t or TJ/m ³] of fuel i
OF_i	is the oxidation factor (dimensionless) of fuel i

¹⁵ Section B.3.1.1, Annex II – European Commission – Implementing Regulation 2023/1773 ([Link](#))

C_{ash}	is the carbon contained in ash and flue gas cleaning dust
C_{total}	is the total carbon contained in the fuel combusted.

Source: Implementing Regulation 2023/1773 – [Link](#)

3.3 Attribution of indirect emissions

Indirect emissions cover the production of electricity that is consumed during the production of CBAM goods, and it is calculated as the amount of electricity consumed multiplied with the applicable emission factor for electricity, as shown in the following formula:

$$AttrEm_{indir} = E_{el,cons} \times EF_{el}$$

Table 5 Glossary of terms for attribution of indirect emissions

$AttrEm_{indir}$	attributed indirect emission of the production process over the whole reporting period (tCO ₂ e)
$E_{el,cons}$	electricity consumed expressed in MWh or TJ
EF_{el}	emissions factor for the electricity applied, expressed in tCO ₂ /MWh or tCO ₂ /TJ

Source: Implementing Regulation 2023/1773 – [Link](#)

For determining the emission factor of electricity (EF_{el}), the following possibilities exist¹⁶:

General case: the general rule for the determination of the emission factor is to use the default values:

- For the transitional period, the default emission factors for electricity are based on data from the International Energy Agency (IEA) covering a 5-year average. They are provided per country by the European Commission in the CBAM Transitional Registry.
- Other emission factors based on publicly available data (emission factor for electricity or the CO₂ emission factor may be used).

Use of actual emission factors, in the case of:

- direct technical link between the installation in which the imported good is produced and the electricity generation source, or
- The operator of the installation has concluded a power purchase agreement with a producer of electricity located in a third country for an amount of electricity that is equivalent to the amount for which the use of a specific [emission factor] value is claimed.

* Market-based specific emission factors, determined for example by Guarantees of Origin or Green Certificates, cannot be used to justify the use of actual emission factors.

3.4 Specific embedded emissions

The specific embedded emissions indicate the amount of CO₂ emitted per unit the product produced (unit: tCO₂/unit). It should be kept in mind that during the transitional period, both direct and indirect emissions should be calculated and reported for all CBAM covered goods. For simple goods, the specific embedded emissions results from the division of the total CO₂ emissions from production by the total production

$$SEE_g = \frac{AttrEm_g}{AL_g}$$

For complex goods using precursors as input, which is the case for many fertilisers and mixed fertilisers, the division of total CO₂ emissions by total production is then summed with the multiplication of the amount of precursors used per unit of production, with the total specific embedded emissions of the precursors as portrayed below.

¹⁶ Q69 - European Commission – Questions & Answers ([Link](#))

$$SEE_g = \frac{AttrEm_g + \sum_{i=1}^n m_i \times SEE_i}{AL_g}$$

Table 6 Glossary of terms for specific embedded emissions for simple goods

SEE_g	Specific embedded direct and indirect emissions
$AttrEm_g$	attributed direct and indirect emission of the production process over the whole reporting period (tCO ₂ e)
AL_g	amount of goods produced in the reporting period in that installation.
m_i	mass of input material (precursor) i used in the production process
SEE_i	Specific embedded (direct and indirect) emissions of input material (precursor) i.

Source: Guidance document on CBAM implementation for installation operators outside the EU – [Link](#)

4 Mixed fertilizer example from the European Commission

4.1 System boundaries

For fertiliser production, defining system boundaries requires defining production routes and processes. In the case of mixed fertilisers, it is also important to consider which precursors used during production are relevant to CBAM, and fall within system boundaries (e.g. during granulation, drying and heating, etc.), to include their embedded emissions. Urea and Ammonia are precursors in CBAM scope while Phosphoric Acid, Sulphuric Acid, Single Super Phosphate and KCl are not.

To exemplify the process, mixed fertiliser (NPK 15-15-15), produced by mixing and granulation will be considered.

For this analysis, the elements considered within the system boundaries, and therefore included in the emissions calculation, are shown in Figure 1.

- **Inputs of the process:** raw materials (here natural gas), relevant precursors (urea and ammonia), and electricity from the grid. Other inputs, not in CBAM scope are in this case phosphoric acid, sulphuric acid, Single Super Phosphate (SSP), and potassium chloride (KCl).
- **Outputs of the process:** the mixed fertiliser produced (NPK 15-15-15)

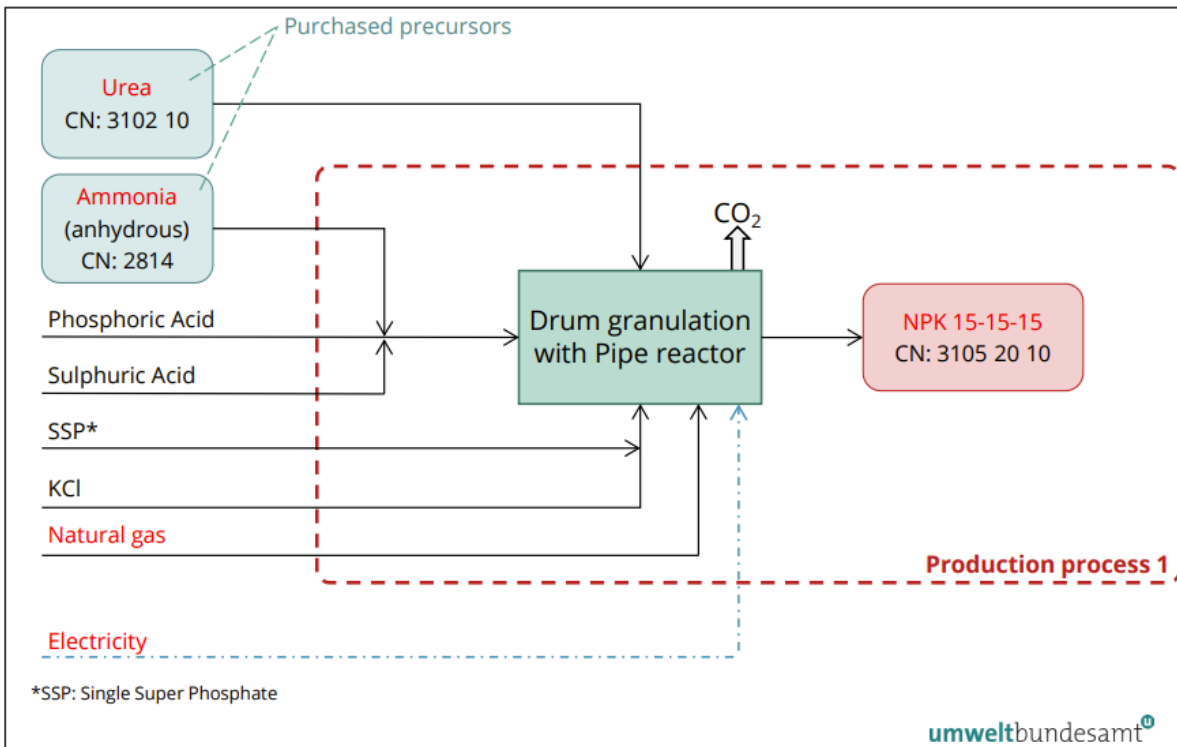


Figure 1 System boundary for mixed fertiliser production

For this specific example, we will consider a fertiliser production plant using drum granulation and a pipe reactor based on the European Commission example. For calculating the emissions, the **standard method will be used**. As the fertiliser production process can produce different fertiliser grades (or formulations) using different amount of precursors, when monitoring, it is important to consider the mass of precursor used per fertiliser grade and the specific embedded emissions associated with it.

4.2 Attribution of direct emissions Granuator / pipe reactor

The following inputs and outputs are the parameters used in the calculations:

Natural gas: 668 (t)

Electricity: 720 MWh

Fertilizer production: 100,000 (t)

The combustion emissions shall be calculated using the standard method as follows:

$$Em_i = AD_i \times EF_i \times OF_i$$

$$AD_i = FQ_i \times NCV_i$$

Where;

Natural gas (NCV= 48 GJ/t), (EF = 56.1 t CO₂/TJ), FQ (668 t)

$$AD_i = 668 \text{ t} \times 48 \text{ GJ/t} = 32,064 \text{ GJ}$$

$$Em_i = \frac{32064}{1000} \text{ TJ} \times 56,1 \frac{\text{t CO}_2}{\text{TJ}} \times 1 \cong 1,800 \text{ tCO}_2$$

4.3 Attribution of indirect emissions Granulator / Pipe reactor

$$AttrEm_{indir} = E_{el,cons} \times EF_{el}$$

$$E_{el,cons} = 720 \text{ MWh}$$

$$EF_{el} = 0.833 \text{ tCO}_2/\text{MWh}$$

$$AttrEm_{indir} = 720 \text{ MWh} \times 0.833 \text{ tCO}_2/\text{MWh} \cong 600 \text{ t CO}_2$$

Summary attribution of direct and indirect emissions

	Consumption	Direct emissions (t CO ₂)	Indirect emissions (t CO ₂)
Natural gas	668 (t)	1,800	
Electricity	720 (MWh)		600
NPK fertiliser	100,000 (t)	0.018 tCO ₂ /T	0.006 tCO ₂ /T

4.4 Attribution of precursors emissions

Precursors

Precursor embedded emissions (tCO ₂ /t)				Fertiliser embedded emissions (tCO ₂ /t)			
Ammonia (tCO ₂ /t)		Urea (tCO ₂ /t)		Ammonia (93 kg/t)		Urea (160 kg/t)	
Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
1,900	0.208	0.719	0.178	0.177	0.019	0.115	0.028

Precursor embedded emissions are those emissions emitted during the production of the precursors themselves, while embedded emissions are proportional to the amount of precursors used in final fertiliser products.

The only output of the process considered is the mixed fertiliser NPK 15-15-15.

Estimating Ammonia direct emissions

Below it is shown how to estimate that direct embedded emissions for ammonia (relevant precursor in the NPK mixed fertiliser production) corresponds to 1,900 tCO₂/t NH₃ (as per the guidance document issued by the European Commission). This information is key to calculate what percentage of emissions in Ammonia production are attributable to the production of hydrogen and subsequently how much emissions savings are obtained, if production of the NPK fertilizer is produced with renewable hydrogen-based Ammonia instead of grey hydrogen under the CBAM method for the transitional phase.

To produce one tonne of ammonia, it is estimated that 180 kg, or 0.18 t of hydrogen are needed¹⁷. As per calculations conducted in the Hydrogen Toolkit paper, to produce one tonne of Hydrogen through SMR, 8.1 tonnes of CO₂ direct emissions are emitted:

Tonnes of Hydrogen	Tonnes of CO ₂ emissions
21,600	176,820.019
1	8,186

In this context, we assume that to produce 1 tonne of hydrogen through the SMR route: 8.2 t of CO₂ are emitted.

Thus, the 0.18 t of hydrogen needed to produce one tonne of ammonia, emit approximately 1.5 t CO₂. The remaining 0.4tCO₂ is attributed to direct emissions (which brings a total emission of 1.9 tCO₂) and are associated with the production process in itself – namely, the combustion of natural gas or other fuels for process heat, electricity generation, and auxiliary systems in the Haber-Bosch production process.

Based on the above it can be determined that grey hydrogen production contributes to approx. 71.4% of CO₂ emissions per tonne of ammonia produced, which a great mitigation potential for green hydrogen.

¹⁷ Hydrogen Europe 2023, Clean Ammonia in the future energy system. [\(See more\)](#)

For a better understanding of emissions in ammonia production, a recent study¹⁸ provides a clear explanation of both process and combustion-related emissions, as well as deductions for exported steam and CO₂. It serves as a useful reference when applying methodologies such as Equation 48 from Section 3.1.1 of the Implementing Regulation (EU) 2023/1773 for calculating attributed direct emissions in line with CBAM requirements.

Estimating ammonia indirect emissions

Indirect emissions for ammonia production depend on the consumption of electricity per tonne of ammonia. For this example and to produce 1 tonne of Ammonia 0.825 MWh of electricity is consumed. The emission factor used equals:

$$0.252 \text{ tCO}_2 / \text{MWh} \quad 19$$

Indirect emissions thus correspond to:

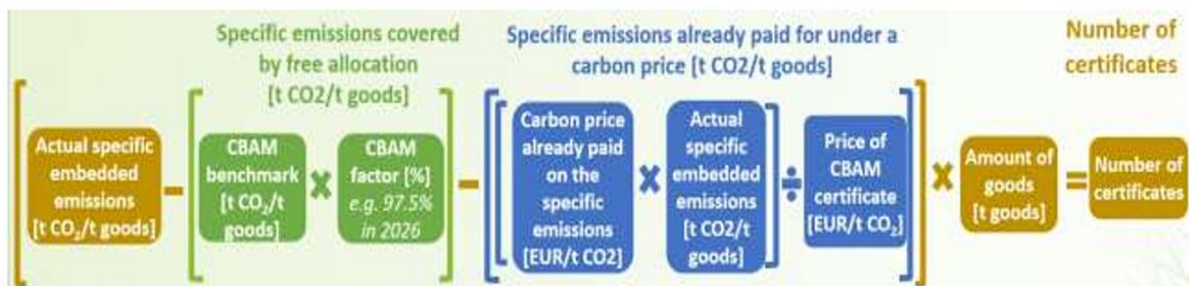
$$\begin{aligned} AttrEm_{indir} &= E_{el,cons} \times EF_{el} \\ AttrEm_{indir} &= 0.825 \text{ MWh/t} \times 0.252 \text{ tCO}_2 / \text{MWh} \\ AttrEm_{indir} &= 0.208 \text{ tCO}_2 / \text{tNH}_3 \end{aligned}$$

Summary:

	Aggregate goods category	Mass t	SEE (direct) tCO ₂ e /t	SEE (indirect) tCO ₂ e/t	SEE (Total) tCO ₂ e /t	Mass t	EmbEm (direct) tCO ₂ e	EmbEm (indirect) tCO ₂ e	EmbEm (Total) tCO ₂ e
Total production process	Mixed fertilisers	1	0.310	0.054	0.364	100,000			36,400
<i>Granulator / Pipe reactor</i>	Mixed fertilisers	1	0.018	0.006	0.024	100,000	1,800	600	2,400
<i>Urea (purum)</i>	Urea	0.160	0.115	0.029	0.144	16,000	11,500	2,900	14,400
<i>Ammonia (unhydrous)</i>	Ammonia	0.093	0.177	0.019	0.196	9,300	17,700	1,900	19,600

4.5 CBAM cost calculation

This section outlines the formula used to calculate the number of CBAM certificates required and the corresponding financial obligation under CBAM. The calculation is based on the formula provided by the European Commission as part of the FAQ document, in particular question 131. As several elements not just of the formula below but also of CBAM design are being reviewed, this section is just for explanatory purposes and should never be understood as any sort of advice for the calculation of the CBAM costs or certificates needed to offset emissions.



The following assumptions are applied in the calculation:

¹⁸ Elshishini, S. (2024). Product carbon footprint methodology for ammonia production by conventional steam reforming—A case study. European Journal of Sustainable Development Research, 8(1), em0241. <https://doi.org/10.29333/ejosdr/13889>

¹⁹ The data used for this example comes from the example provided by the European Commission DG Taxud and available online. [\(Link\)](#)

1. As CBAM benchmarks have not been yet published/adopted a value of 0.02 tCO₂e/t has been used.
2. No carbon price has been paid in the country of origin.
3. CBAM factor applied corresponds to the year 2030

Direct embedded emissions from mixed fertiliser production must consider the direct embedded emissions from precursor (ammonia and urea) and energy use, in this case amounting to 0.310 tCO₂/t.

Thus, for the import of 100,000 tonnes of NPK 15-15-15 fertiliser, we would have the following:

$$100,000t \times 0.310tCO_2/t = 31,000tCO_2$$

Indirect emissions, similarly, amount to 0.054 tCO₂/t of fertiliser produced.

For the import of 100,000 tonnes of NPK 15-15-15, we thus have the following amount of indirect embedded emissions:

$$100,000t \times 0.054tCO_2/t = 5,400tCO_2$$

100,000 tonnes of NPK 15-15-15 imported thus equals to the import of a total of 36,400t CO₂.

Similarly, 0.16 tonnes (m₁) of Urea imported thus equals to the import of a total of 14,400 tCO₂ (SEE₁) and 0.093 tonnes (m₂) of Ammonia corresponds to the import of a total of 19,600 tCO₂ (SEE₂).

- To calculate specific embedded emission as per Section **Error! Reference source not found.**:

$$SEE_g = \frac{AttrEm_g + \sum_{i=1}^n m_i \times SEE_i}{AL_g}$$

$$SEE_g = \frac{2400 + (9300 \times 2,108) + (16000 \times 0,897)}{100000} = 0,3635 \cong 0.364$$

- To Calculate the no. of certificates:

$$\text{No. of certificates} = (0.364 - (0.02 \times 0.515) - (0)) \times 100000 \cong 35,370$$

Taking the EU ETS price forecast for 2030 at 149€²⁰ per tonne of carbon²¹, CBAM price for the imported fertiliser would be the following:

$$35,370 \times 149\text{€} = 5,270,130\text{€}$$

Thus, following CBAM-emissions calculation methodology, and estimated 2030 EU ETS prices, importing 100,000 tonnes of NPK 15-15-15 fertiliser conventional (not renewable) would require paying an extra cost of **5,270,130€** for carbon emissions.

5 Renewable hydrogen-based mixed fertiliser example

5.1 System boundaries

In this case to produce the mixed fertilizer, renewable hydrogen (RFNBO) will be used for Ammonia production and renewable electricity will be used for all production processes where indirect emissions are generated as a result of the production process, thereby assuming an emission factor of 0.

²⁰ If a carbon price has been paid in the country of origin, this will be taken into account and discounted from the ETS price

²¹ As per BloombergNEF (<https://about.bnef.com/blog/europes-new-emissions-trading-system-expected-to-have-worlds-highest-carbon-price-in-2030-at-e149-bloombergnef-forecast-reveals/>)

Renewable hydrogen is defined as hydrogen produced using renewable electricity through the process of electrolysis, which if compliant with the EU Renewable Energy Directive and Delegated Acts would fall under the categorization of RFNBO (Renewable Fuel of Non-Biological Origin).²²

For this analysis, the elements considered within the system boundaries, and therefore included in the emissions calculation, are shown in Figure 1.

- **Inputs of the process:** raw materials (here natural gas), relevant precursors (urea and ammonia produced with renewable hydrogen), and electricity from renewable sources. Other inputs, not relevant to CBAM, are in this case phosphoric acid, sulphuric acid, Single Super Phosphate (SSP), and potassium chloride (KCl).
- **Outputs of the process:** the mixed fertiliser produced (NPK 15-15-15)

5.2 Attribution of direct emissions Granulator / pipe reactor

The following inputs and outputs are the parameters used in the calculations:

Natural gas: 668 (t)

Electricity: 720 MWh

Fertilizer production: 100,000 (t)

The combustion emissions shall be calculated using the standard method as follows:

$$Em_i = AD_i \times EF_i \times OF_i$$

$$AD_i = FQ_i \times NCV_i$$

Where;

Natural gas (NCV= 48 GJ/t), (EF = 56.1 t CO₂/TJ), FQ (668 t)

$$AD_i = 668 \text{ t} \times 48 \frac{\text{GJ}}{\text{t}} = 32064 \text{ GJ}$$

$$Em_i = 32064/1000 \text{ TJ} \times 56,1 \text{ t CO}_2/\text{TJ} \times 1 \cong 1800 \text{ tCO}_2$$

5.3 Attribution of indirect emissions Granulator / Pipe reactor

$$AttrEm_{indir} = E_{el,cons} \times EF_{el}$$

$$E_{el,cons} = 720 \text{ MWh}$$

$$EF_{el} = 0 \text{ t CO}_2/\text{MWh}$$

$$AttrEm_{indir} = 0 \text{ t CO}_2$$

Summary attribution of direct and indirect emissions

	Consumption	Direct emissions (tCO ₂)	Indirect emissions (t CO ₂)
Natural gas	668 (t)	1800	
Electricity	720 (MWh)		
NPK fertiliser	100,000 (t)	0.018 tCO ₂ /T	0 TCO ₂ /T

5.4 Attribution of precursors emissions

Precursors

²² RFNBO renewable liquid and gaseous transport* fuels of non-biological origin means liquid or gaseous fuels which are used in the transport sector other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass RIED II - European Commission – Directive 2018/2001 ([Link](#))

Precursor embedded emissions (tCO ₂ /t)				Fertiliser embedded emissions (tCO ₂ /t)			
Ammonia (tCO ₂ /t)		Urea (tCO ₂ /t)		Ammonia (93 kg/t)		Urea (160 kg/t)	
Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
0.57	0	0.719	0	0.053	0	0.115	0

Precursor embedded emissions are those emissions emitted during the production of the precursors themselves, while embedded emissions are proportional to the amount of precursors used in final fertiliser products.

The only output of the process considered is the mixed fertiliser NPK 15-15-15.

5.5 Calculating ammonia direct emissions

As explained in Section 4.4, for this example we assume that grey hydrogen production contributes to approx. 71.4% of CO₂ emissions per tonne of ammonia, representing a great mitigation potential for renewable hydrogen. In this case we have reduced by 70% the amount of direct emissions for Ammonia production.

$$\text{Direct emissions} = 1.9 \text{ tCO}_2/\text{t} \times 0.3 = 0.57 \text{ tCO}_2/\text{t}$$

5.6 Calculating ammonia indirect emissions

Indirect emissions for ammonia production depend on the consumption of electricity per tonne of ammonia. In this example we assume that electricity is from renewable sources and an emission factor of 0 has been attributed.

Indirect emissions thus correspond to:

$$\begin{aligned} \text{AttrEm}_{indir} &= E_{el,cons} \times EF_{el} \\ \text{AttrEm}_{indir} &= 0.825 \text{ MWh/t} \times 0 \text{ tCO}_2/\text{MWh} \\ \text{AttrEm}_{indir} &= 0 \text{ tCO}_2/\text{t NH}_3 \end{aligned}$$

Summary:

Granulator / Pipe reactor	Aggregated goods category	Mass t	SEE (direct) tCO _{2e} /t	SEE (indirect) tCO _{2e} /t	SEE (total) tCO _{2e} /t	EmbEm (direct) tCO _{2e}	EmbEm (indirect) tCO _{2e}	EmbEm (total) tCO _{2e}
Total production process	Mixed fertilisers		0.257	0	0.186			18,601
<i>Granulator / Pipe reactor</i>	Mixed fertilisers	100,000	0.018	0	0.018	1,800	0	1,800
<i>Urea (purum)</i>	Urea	0.160	0.115	0	0.115	11,500	0	11,500
<i>Ammonia (unhydrous)</i>	Ammonia	0.093	0.053	0	0.053	5,301	0	5,301

Assuming a reduction of 70% of Ammonia direct emissions by introducing certified renewable hydrogen (RFNBO) and a reduction of 100% of all indirect emissions under scope as electricity is provided from renewable sources thereby assuming the use of an emission factor of 0, total GHG savings are presented as follows:

Summary:

Granulator / Pipe reactor	Aggregated goods category	Mass t	SEE (total) tCO _{2e} /t	SEE (total) tCO _{2e} /t
Total production process	Mixed fertilisers		0.364	0.186
<i>Granulator / Pipe reactor</i>	Mixed fertilisers	100,000	0.024	0.018
<i>Urea (purum)</i>	Urea	0.160	0.144	0.115
<i>Ammonia (unhydrous)</i>	Ammonia	0.093	0.196	0.053

6 Conclusion

This document describes the application of the CBAM method for the transitional phase for the calculation of embedded direct and indirect greenhouse gas emissions in relation to a concrete example of a NPK mixed fertilizer. The objective of this guidance document is twofold:

On the one side it provides a step by step explanation of how to apply the CBAM method to a NPK mixed fertilizer good during the transitional phase and on the other side; It calculates the GHG emissions savings under the CBAM method assuming grey hydrogen is replaced by certified renewable hydrogen (RFNBO) for ammonia production and all indirect emissions involved in the production process are attributed an emission factor of 0 (assuming electricity comes from renewable sources via a direct connection with a renewable energy generation facility).

The methodology has been applied in accordance with COMMISSION IMPLEMENTING REGULATION (EU) 2023/1773 and REGULATION (EU) 2023/956, which lay down the reporting obligations and calculation rules under the Carbon Border Adjustment Mechanism (CBAM).

Remarks:

- The use of RFNBOs certificates allow for the use of an emission factor of 0 when calculating hydrogen indirect emissions. If such a certificate has not been obtained or is not available, indirect emissions should be calculated according to the relevant section of the implementing regulation.
- During the transitional period, the general rule for the emission factor for electricity is to use default values which will be provided by the Commission. However, actual emission factors for electricity can be used if the relevant conditions are met (i.e., existence of a direct technical link or a power purchase agreement etc.). Market-based specific emission factors, determined for example by Guarantees of Origin or Green Certificates, cannot be used to justify the use of actual emission factors.
- Site-specific data should be used where available to improve accuracy and credibility on embedded emissions. This is especially the case when site-specific emissions are lower than default values as lower embedded emissions will translate into lower CBAM costs. Any assumptions or data gaps addressed during calculations must be transparently documented.
- Availability and use of up to date and CBAM compliant emissions factors is essential to guarantee that decarbonization efforts are translated into CBAM monitoring and reporting requirements.
- By replacing grey hydrogen by certified renewable hydrogen (RFNBO), direct emissions of ammonia production can be reduced by approx. 70% per ton when applying the CBAM method. In practical terms, this reduction of emissions will be translated into lower CBAM costs.
- In the example provided emissions of producing the NPK mixed fertilizer can be reduced by approx. 50% if certified renewable hydrogen (RFNBO) is introduced and an emission factor of 0 (renewable electricity) is used for all indirect emissions resulting from the production process. This reduction in emissions will be translated into a equivalent reduction of CBAM costs.

Notes:

During the definitive period, the CBAM methodology will be updated to reflect future policy and regulatory developments. Therefore, the information provided in this guided document will also be updated accordingly.

Annexure I

All CN codes for fertilisers (under CBAM):

- Mineral or chemical fertilisers, nitrogenous: 3102
 - Ammonium sulphate: 3102 21 00
 - Other: 3102 29 00
 - Ammonium nitrate, whether or not in aqueous solution: 3102 30
 - In aqueous solution: 3102 30 10
 - Other: 3102 30 90
 - Mixtures of ammonium nitrate with calcium carbonate or other inorganic non-fertilising substances: 3102 40
 - With a nitrogen content not exceeding 28 % by weight: 3102 40 10
 - With a nitrogen content exceeding 28 % by weight: 3102 40 90
 - Sodium nitrate: 3102 50 00
 - Double salts and mixtures of calcium nitrate and ammonium nitrate: 3102 60 00
 - Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution: 3102 80 00
 - Other, including mixtures not specified in the foregoing subheadings: 3102 90 00
- Mineral or chemical fertilisers containing two or three of the fertilising elements nitrogen, phosphorus, and potassium; other fertilisers; goods of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg: 3105
 - Fertiliser goods in tablets or similar forms or in packages of a gross weight not exceeding 10 kg: 3105 10 00
 - Mineral or chemical fertilisers containing the three fertilising elements nitrogen, phosphorus, and potassium: 3105 20
 - With a nitrogen content exceeding 10 % by weight on the dry anhydrous product: 3105 20 10
 - Other: 3105 20 90
 - Diammonium hydrogenorthophosphate (diammonium phosphate): 3105 30 00
 - Ammonium dihydrogenorthophosphate (monoammonium phosphate) and mixtures thereof with diammonium hydrogenorthophosphate (diammonium phosphate): 3105 40 00
 - Other mineral or chemical fertilisers containing the two fertilising elements nitrogen and phosphorus:
 - Containing nitrates and phosphates: 3105 51 00
 - Other: 3105 59 00
 - Other: 3105 90
 - With a nitrogen content exceeding 10 % by weight on the dry anhydrous product: 3105 90 20
 - Other: 3105 90 8

Annexure II

Supporting Formulae Related to Equation (3.1.1, Tabel 3)

1. If this heat is supplied externally — e.g., via purchased steam or hot water from a third party or another facility — then heat import emissions must be accounted for using Formula A.1

Formula A.1: $Em_{H,imp} = Q_{imp} * EF_{heat}$

Where:

Q_{imp} = is the net heat imported to and consumed in the production process expressed in TJ.

EF_{heat} = is the emission factor for the production of measurable heat determined in accordance with Section C.2 of Implementing Regulation 2023/1773, expressed in t CO₂/TJ

Formula A.1 calculates the total emissions associated with heat imported and consumed within the production process. The variable Q_{imp} represents the total quantity of imported heat energy, expressed in terajoules (TJ), and EF_{heat} is the corresponding emission factor, expressed in tons of CO₂ per terajoule, determined as per Section C.2 of Implementing Regulation (EU) 2023/1773. This calculation is essential to ensure that indirect emissions from externally sourced heat are accounted for in the overall emissions footprint of the installation, in alignment with CBAM requirements.

2. In some cases, ammonia plants may receive waste gases (like refinery off-gas or process vent gas) from other plants. If these gases are used as fuel for reforming furnaces or boilers, their emissions must be reported using Formula A.2, as if they were natural gas, to maintain standardization.

Formula A.2: $WG_{corr,imp} = V_{WG} * NCV_{WG} * EF_{NG}$

Where:

V_{WG} = is the volume of the waste gas imported

NCV_{WG} = is the net calorific value of the waste gas imported

EF_{NG} = is the standard emission factor of natural gas as given in Annex VIII of Implementing Regulation 2023/1773.

Formula A.2 is used to calculate the corrected emissions associated with the use of imported waste gas in the production process. Here, V_{WG} denotes the volume of waste gas imported, NCV_{WG} refers to its net calorific value, and EF_{NG} is the standard emission factor for natural gas as stipulated in Annex VIII of Implementing Regulation (EU) 2023/1773. By expressing the emissions from waste gas combustion in terms of an equivalent natural gas reference, this method ensures consistency in emission reporting regardless of the fuel type used.

3. In some cases, ammonia production may generate some waste gases and if these gases are exported (e.g., sent to a hydrogen recovery unit, or for use in other plants), the emissions credit must be adjusted using Formula A.3, to reflect the reduced efficiency in their use elsewhere.

Formula A.3: $WG_{corr,exp} = V_{WG;exp} * NCV_{WG} * EF_{NG} * Corr_{\eta}$

Where:

$V_{\text{WG;exp}}$ = is the volume of waste gas exported from the production process

NCV_{WG} = is the net calorific value of waste gas

EF_{NG} = is the standard emission factor of natural gas as given in Annex VIII of Implementing Regulation 2023/1773

Corr_{η} = is the factor that accounts for the difference in efficiencies between the use of waste gas and the use of the reference fuel natural gas. The standard value is $\text{Corr}_{\eta} = 0,667$

Formula A.3 determines the corrected emissions related to waste gas exported from the production process. $V_{\text{WG;exp}}$ is the volume of exported waste gas, NCV_{WG} is its net calorific value, and EF_{NG} is the standard natural gas emission factor. The factor Corr_{η} , with a default value of 0.667, accounts for the lower energy conversion efficiency typically associated with using waste gas compared to natural gas. This adjustment prevents overestimation of emission reductions by incorporating a standard correction for efficiency loss, ensuring accurate and conservative reporting under CBAM.



The International Hydrogen Ramp-up Program (H2Uppp) is supporting entrepreneurial engagement in the ramp-up of hydrogen in the Global South and is a funding program of the:



Implementation by:

