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MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

Promoting Enhanced EU ETS Alignment in Türkiye's Emerging ETS

This activity is part of the European Union Climate Dialogues Project (EUCDs)

Fertilizers sector

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MODULE 2 — CBAM-RELEVANT PRODUCT BENCHMARKS BY SECTOR

Online Day 5 — Fertilizers

Production of fertilizers — CO2 accountability, EU ETS benchmarks, system boundaries, urea & mixed fertilizers, and CBAM

Nitric acid
Adipic acid

Ammonia

Soda ash

Experts: F. Romani / M. Franke · TR ETS Benchmarking Training — EU Climate Dialogues 2, Türkiye



CONTINUITY WITH DAYS 2–3

From steel, cement, aluminium to fertilizers — what carries over, what changes

Same framework as before

- Product benchmarks = average of the 10% best EU installations
- Free allocation = $BM \times HAL \times CLEF \times CBAM \text{ factor}$
BM = benchmark · HAL = historical activity level · CLEF = carbon-leakage exposure factor
- Carbon-leakage list → $CLEF = 1$ (100%)
- Sub-installations, baseline data reports (BDR), verified MRV — the same chain

What is different for Fertilizers

- Process emissions dominate: CO₂ from feedstock & carbonates, N₂O from HNO₃ / adipic acid
- Carbon leaves in products (urea, soda ash) → mass-balance MRV
- N₂O requires continuous emission measurement (CEMS)
- Four product benchmarks — but only NH₃ & HNO₃ are CBAM goods
- CO₂ is also a feedstock: transferred-CO₂ rules (Art. 48–49a MRR)



DAY 5

Agenda for the day

1

Introduction: Fertilizers in the EU ETS and CBAM

2

How the CO₂ is counted (MRV)

3

EU ETS benchmarks — ammonia, nitric acid, adipic acid and soda ash

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System boundaries & sub-installations

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Worked example: Integrated fertilizer complex sub-installation map

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Urea & mixed fertilizers: production, CO₂ and monitoring

7

CBAM and fertilizers



SECTION 1 · SCOPE

Fertilizer production in the EU ETS — activities, gases, products

Annex I activity (Dir. 2003/87/EC)	Threshold	GHG covered	Typical products
Production of ammonia	None	CO ₂	NH ₃ (merchant or for urea / AN)
Production of nitric acid	None	CO ₂ + N ₂ O	HNO ₃ 30–70 %+ (for AN, CAN, NPK)
Production of adipic acid	None	CO ₂ + N ₂ O	Purified adipic acid (nylon 6,6)
Production of soda ash / sodium bicarbonate	None	CO ₂	Na ₂ CO ₃ , NaHCO ₃ (Solvay process)
Combustion of fuels in installations	> 20 MW total rated thermal input	CO ₂	Steam / heat for granulation, drying, prilling
Bulk organic chemicals (cracking, reforming, oxidation)	> 100 t/day	CO ₂	Urea via NH ₃ + CO ₂ (if not in NH ₃ permit)

No capacity threshold: ammonia, nitric acid, adipic acid and soda ash production are in the EU ETS at any size — unlike combustion (> 20 MW). Fertilizer finishing plants (granulation, blending) without these activities enter only via the combustion activity.

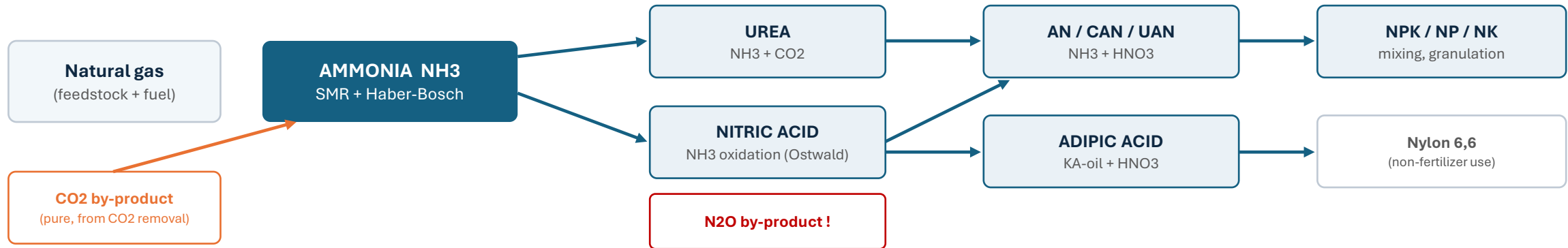
Aggregation rule: where several activities are carried out in the same installation, the permit and the monitoring plan cover them all; capacities of the same activity are added (gd0 §3).

Directive 2003/87/EC Annex I · gd0 Guidance on Interpretation of Annex I (2024), §4 and Annex I table



SECTION 1 · TECHNOLOGY

Main production routes — one carbon and nitrogen value chain



Process descriptions: GD9 §§39–41, 52 · CBAM Guidance for Importers §5.5.3 (value-chain overview)



SECTION 1 · CHEMISTRY

The reactions behind the value chain — and where the gases arise

Process step / reaction	What happens	GHG consequence
Reforming: $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3 \text{H}_2$	natural gas + steam $\rightarrow$ hydrogen (endothermic, gas-fired)	combustion CO_2 in the reformer flue gas; process CO_2 appears after the shift and CO_2 removal.
Shift: $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$	more H_2 ; ALL feed carbon ends up as CO_2	process CO_2 — removed as a nearly pure stream
Haber-Bosch: $\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$	ammonia synthesis at ~200 bar over Fe catalyst	no CO_2 from the reaction itself — energy use only
Ostwald: $4 \text{NH}_3 + 5 \text{O}_2 \rightarrow 4 \text{NO} + 6 \text{H}_2\text{O}$	$\text{NO} \rightarrow \text{NO}_2$, absorbed in water $\rightarrow \text{HNO}_3$ (exothermic)	N_2O by-product over the Pt/Rh gauze — unwanted, unavoidable
Urea: $2 \text{NH}_3 + \text{CO}_2 \rightarrow \text{CO}(\text{NH}_2)_2 + \text{H}_2\text{O}$	via ammonium carbamate; CONSUMES CO_2	binds 0.733 t CO_2 / t urea — re-released later in the field
Neutralisation: $\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3$	ammonium nitrate for AN / CAN / NPK finishing	no CO_2 ; the N_2O legacy sits in the HNO_3 precursor

Read the last column top to bottom: the same molecules keep reappearing — the CO_2 made by reforming is consumed by urea; the NH_3 from Haber-Bosch feeds both nitric acid and urea. This internal recycling is exactly why CO_2 attribution rules and system boundaries dominate the rest of this day.

Process chemistry: GD9 §§39–41 · CBAM Guidance for Importers §5.5.3 · MRR (EU) 2018/2066 Annex VI



SECTION 1 · CONTEXT — OECD STUDY

CBAM along the supply chain — the view for fertilizers and Türkiye

What the OECD (2025) simulation finds

- CBAM covers 3 % of EU imports — metals, fertilizers, cement dominate
- Türkiye among the 3 most exposed exporters: ≈ USD 13.8 bn covered (2022)
- No CBAM → ≈ 19 % carbon leakage; CBAM largely reverses it
- EU demand reroutes to carbon-efficient producers
- Own carbon price = lower border bill

What this means for fertilizer exports to the EU

- **Fertilizers are fully in scope:** direct CO₂ and N₂O plus indirect (electricity) emissions all count for fertilizer goods
- **The ammonia route decides the bill:** gas-based plants with modern N₂O abatement face far lower CBAM costs than coal-based routes
- **A domestic carbon price is deductible:** a functioning Turkish ETS reduces the CBAM certificates its exporters must buy (Art. 9)
- **Efficient plants keep their EU market:** the model shows demand rerouting rewards low-emission producers — verified MRV data is the entry ticket
- **Bottom line:** proving actual embedded emissions is the sector's main competitive asset under CBAM

Scope note: the paper's general findings were presented in earlier sessions — **today we keep only the fertilizer and Türkiye angle** as context for the allocation and CBAM arithmetic of Sections 5 and 7.

OECD STI Working Paper 2025/02 — Dechezleprêtre et al., "Carbon Border Adjustments: The potential effects of the EU CBAM along the supply chain"



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SECTION

2

How CO₂ is counted — Monitoring, Reporting, Verification

Regulation (EU) 2018/2066 (MRR) applied to fertilizer installations: source streams, calculation factors, mass balances, N₂O measurement

In this section

- The CO₂ map: where CO₂ is generated, captured, reused — and where it leaves
- Calculation-based vs measurement-based methodologies — and when each is mandatory
- Mass balance and stoichiometry — counting carbon, not fuel
- Continuous N₂O measurement for nitric and adipic acid
- Hydrogen production routes and how they shape the emission profile
- Worked numerical examples on a carbon flow diagram

Primary legal sources

- Regulation (EU) 2018/2066 (MRR), consolidated 2025
- MRR Annex I (monitoring plan), Annex II (tiers), Annex IV §§16, 17, 20, Annex VI (factors)
- Regulation (EU) 2018/2067 (AVR) for verification



SECTION 2 · THE CO₂ MAP

Where CO₂ is generated, captured, reused — and where it leaves

Where in the plant	What happens to the CO ₂	How the MRR sees it
Reformer & boiler stacks (fired heaters)	dilute combustion CO ₂ leaves with the flue gas — not captured	emission of the installation — inside the mass balance
CO ₂ -removal unit (after the shift reactor)	process CO ₂ captured as a nearly pure stream (~99 %)	not yet an emission — its downstream fate decides
Urea synthesis (on site)	captured CO ₂ reused: bound into CO(NH ₂) ₂ at 0.733 t/t	still counted as emitted by the NH ₃ plant (Annex IV §17)
Merchant CO ₂ — food & beverage, greenhouses	CO ₂ leaves by truck/pipeline for short-lived uses	counted as emitted — no deduction (not Art. 49/49a)
CCS pipeline / permanently binding CCU	CO ₂ leaves for geological storage or mineralisation	deductible from reported emissions (Art. 49, 49a)
Nitric acid tail-gas stack	no CO ₂ here — but the N ₂ O leaves at this point	measured continuously by CEMS (Annex IV §16)

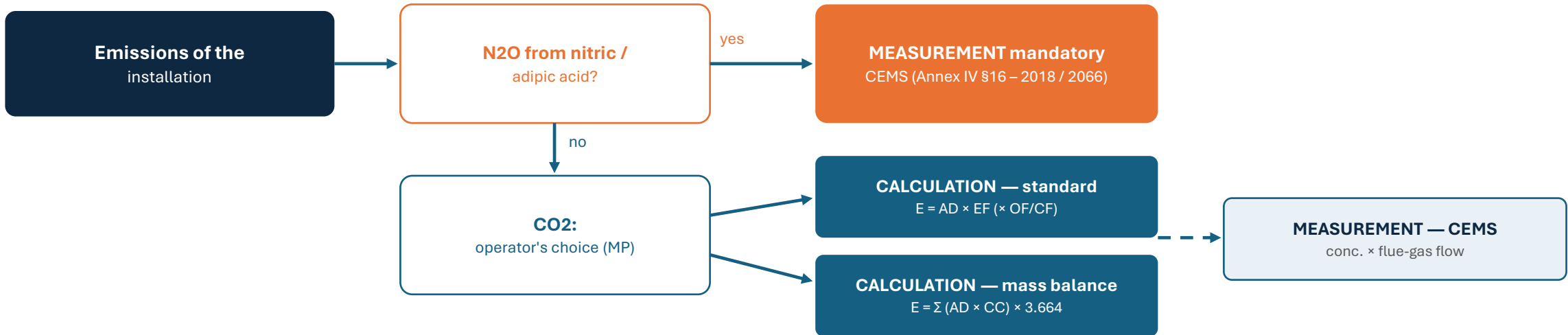
One design principle: every fossil carbon atom is priced exactly once — the rules only decide WHERE it is counted. Follow the pure CO₂ stream: vented = emitted; to urea = emitted here (the field re-releases it); to CCS = deducted. That single principle explains the whole monitoring design for fertilizers.

Regulation (EU) 2018/2066, Annex IV §§16, 17, 20 · Art. 48–49a



SECTION 2 · METHODOLOGY CHOICE

Calculation-based vs measurement-based — Art. 21 decision logic



- **Combining is normal (Art. 21(1)):** one installation may use standard methodology for boilers, mass balance for the integrated NH₃–urea complex, CEMS for N₂O — provided no gaps and no double counting.
- **Switching hierarchy (Art. 21(2)–(3)):** measurement may be used for CO₂ if the operator demonstrates required tiers are met; corroborating calculation is required for CO₂ CEMS.
- **Fall-back (Art. 22):** methodology without tiers only where all tiers are technically infeasible / unreasonable cost — must quantify overall uncertainty (< 7.5 % cat. C).

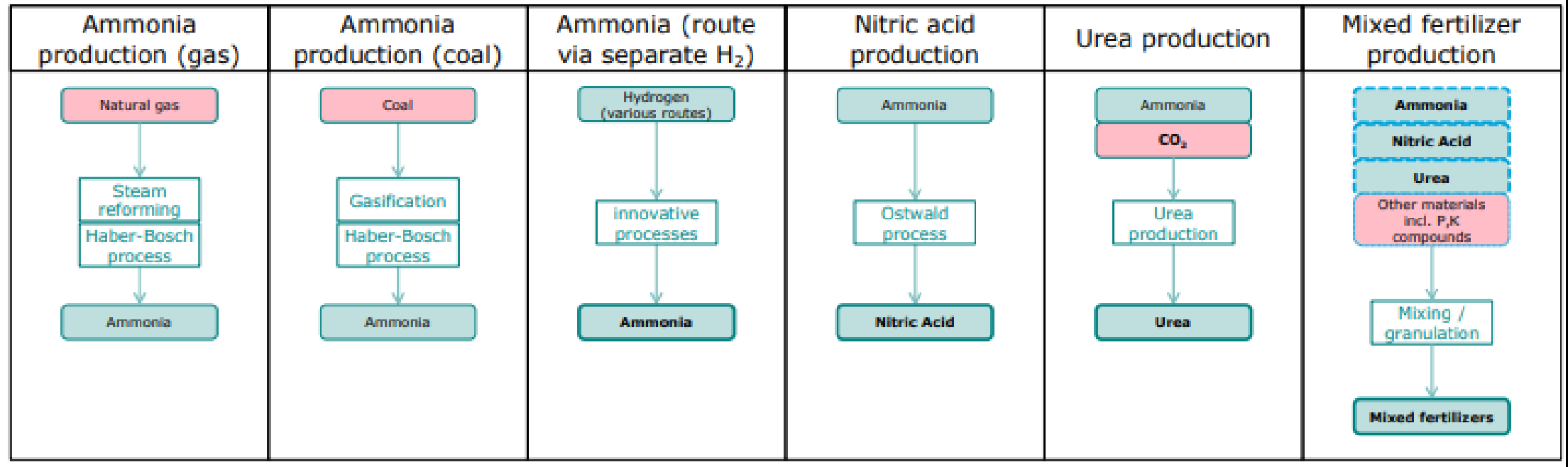
Regulation (EU) 2018/2066, Art. 21–22, 24–25, 40–46; Annex IV §16



SECTION 2 · PRODUCTION ROUTES

Production routes for nitrogenous fertilizers — overview

Production of nitrogenous fertilizer and its precursors – overview



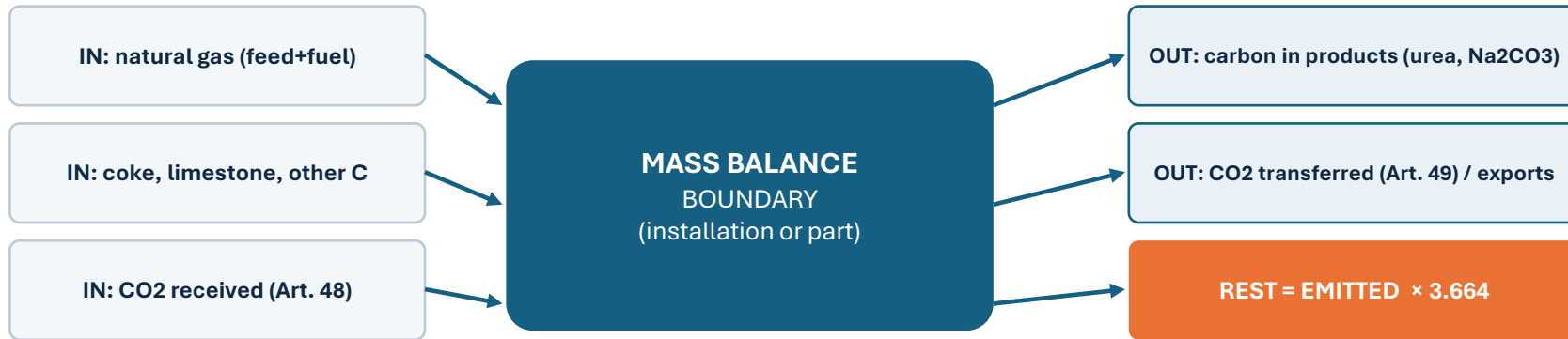


SECTION 2 · CALCULATION — MASS BALANCE

Mass balance (Art. 25): count the carbon, not the fuel

$$Em\ CO_2 = \sum inputs/outputs (AD \times CC) \times 3.664$$

AD counts positive for inputs, negative for outputs (products, exports); CC = carbon content [t C / t]; 3.664 = 44.010/12.011 t CO₂ per t C



Use it when...

- carbon leaves in products or wastes
- inputs are chemically converted, not burnt
- streams are too interlinked to attribute per unit

Carbon balance discipline: every carbon atom that enters must appear once — as product carbon, transferred CO₂ or emission. Tier for CC follows Annex II §3; AD tiers as for standard methodology; biomass carbon per Art. 39.

Regulation (EU) 2018/2066, Art. 25, Art. 39, Annex II §§1.4, 3 · Annex IV §17, §20 (fertilizer applications)



SECTION 2 · PROCESS EMISSIONS & STOICHIOMETRY

Stoichiometric anchors for fertilizer MRV

Reaction / relationship	Factor	Use in MRV
$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ (lime kiln)	0.440 t CO ₂ / t CaCO ₃	Method A carbonate input (Annex VI table 2)
Na ₂ CO ₃ carbon content	0.415 t CO ₂ -equiv. / t Na ₂ CO ₃	Output term in soda ash mass balance
NaHCO ₃ carbon content	0.524 t CO ₂ -equiv. / t NaHCO ₃	Output term (bicarbonate co-product)
$\text{CO}_2 + 2 \text{NH}_3 \rightarrow \text{CO}(\text{NH}_2)_2 + \text{H}_2\text{O}$ (urea)	0.733 t CO ₂ bound / t urea	CO ₂ chemically bound in urea (60.06/44.01)
CH ₄ combustion / reforming	56.1 t CO ₂ / TJ NCV	Natural gas default EF (Annex VI table 1)
N ₂ O global warming potential	265 t CO ₂ (e) / t N ₂ O	Convert measured N ₂ O to CO ₂ (e) (Annex VI §3)

Method A vs Method B for carbonate process emissions (Annex II §4): A = input-based (t carbonate charged × stoichiometric EF, CF for residual carbonate in products); B = output-based (t oxide produced × EF). For Solvay lime kilns Method A on limestone is standard; combine with the CO₂ re-absorption logic of Annex IV §20.

Regulation (EU) 2018/2066, Annex II §4, Annex VI tables 1–2 and §3



SECTION 2 · MEASUREMENT-BASED METHODOLOGY

N2O from nitric & adipic acid: continuous measurement is the law

Annex VIII equations

$$\text{GHG emissions [t]} = \sum h \left(\text{conc.h [g/Nm}^3\text{]} \times \text{flow h [Nm}^3\text{/h]} \right) / 10^6$$

$V_{\text{flue gas}} = V_{\text{air}} \times (1 - \text{O}_{2,\text{air}}) / (1 - \text{O}_{2,\text{flue}})$ (Art. 43(5)(a)
preferred for HNO₃)

$$\text{CO}_2(\text{e}) [\text{t}] = \text{N}_2\text{O} [\text{t}] \times 265$$

Measure at a representative point AFTER the abatement unit; instruments must cover abated AND unabated conditions; dry-gas basis.

Regime by activity (Annex IV §16 B.1)

- **Nitric acid:** continuous emission measurement — no alternative.
- **Adipic acid:** measurement for abated emissions + mass-balance calculation for temporary unabated events (bypass, abatement trips).
- **QA:** EN 14181 (QAL1–3, AST), EN 14789 for O₂; substitution data for missing hours per Annex VIII §5 (conservative averages).

Tier (Annex VIII §1)	1	2	3	4
Max. uncertainty, annual hourly-average based emissions	±10 %	±7.5 %	±5 %	±2.5 %

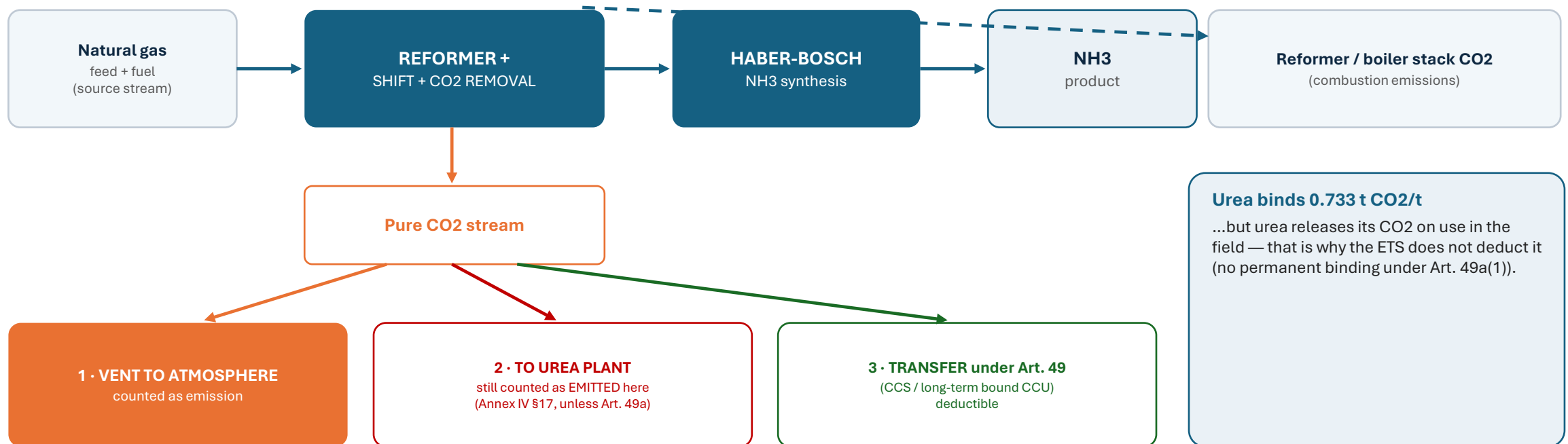
Highest tier required for major emission sources (category C nitric acid plants routinely must justify ±2.5 %). Uncertainty rises during unabated events — include in the uncertainty assessment.

Regulation (EU) 2018/2066, Art. 40–46, Annex IV §16, Annex VIII · GWP: Annex VI §3



SECTION 2 · CARBON FLOWS

Where carbon enters and leaves an ammonia–urea installation



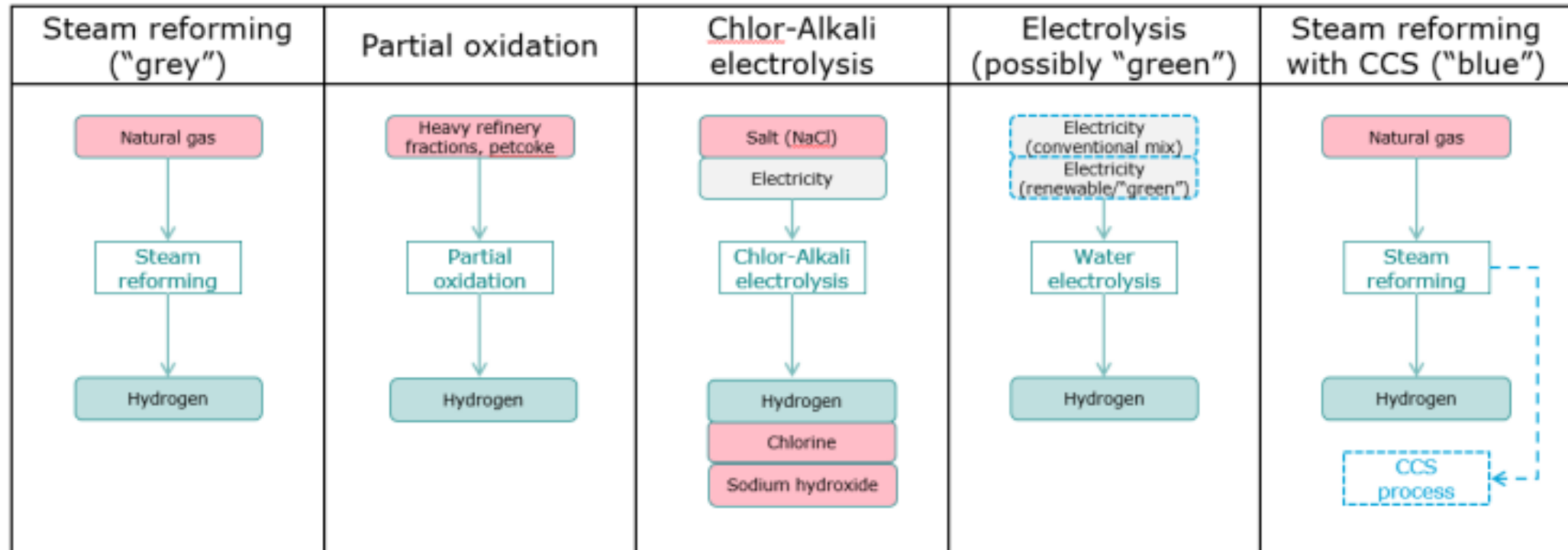
Regulation (EU) 2018/2066, Annex IV §17 (M5), Art. 48–49a · GD values: Annex VI



SECTION 2 · HYDROGEN ROUTES

Hydrogen production routes — five system boundaries

Production routes for hydrogen – overview





SECTION 2 · HYDROGEN ROUTES

How the hydrogen route drives the emission profile

H2 route	How it works	Direct CO2	Indirect (electricity)	Ammonia benchmark?	CBAM view	Typical role
Steam reforming (“grey”)	CH4 + steam → H2 + CO2	high (process + combustion)	moderate	inside BM 41	CCS variant deducts stored CO2	dominant in EU / Türkiye
Partial oxidation / gasification	coal / heavy oil → syngas → H2	very high (≈ 2× gas route)	moderate	inside BM 41	largest embedded emissions	China, legacy plants
Water electrolysis (“green”)	electricity splits H2O	near zero	very high (grid factor)	in BM 41 (2026–30)	SEE (specific embedded emissions) ≈ indirect only	growing (PPAs)
Chlor-alkali by-product H2	by-product of brine electrolysis	low (cell process)	high	EXCLUDED from BM 41	separate precursor, own SEE	niche NH3 feed

Why this figure matters: the H2 route fixes most of ammonia’s emission profile — and urea, AN and NPK inherit it via the precursor rules.

Watch the boundary: H2 made inside an NH3 plant is part of BM 41 — the hydrogen benchmark (BM 50) is for merchant H2 plants only.

CBAM Guidance for Importers §5.4.3 (Fig. 5-3) · GD9 benchmarks 41 & 50 · FAR Annex I as amended (Del. Reg. (EU) 2024/873)



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SECTION

3

EU ETS benchmarks — ammonia, nitric acid, adipic acid, soda ash

Product benchmark logic, system boundaries, values and eligibility for the four fertilizer-chain benchmarks

In this section

- What a benchmark is in practice — and the formula it feeds: $BM \times HAL \times CLEF \times CBAM \text{ factor}$
- The four benchmarks: units, boundaries, inclusions and exclusions
- Treatment of heat, steam, electricity at each boundary
- Carbon leakage status, CBAM status and historical activity levels

Primary legal sources

- Delegated Reg. (EU) 2019/331 (FAR), Annex I — definitions & starting points
- Impl. Reg. (EU) 2021/447 — values 2021–2025
- Impl. Reg. (EU) 2026/1412 — values 2026–2030
- GD9 sector guidance (2024): §§39–41, 52



SECTION 3 · THE FOUR BENCHMARKS

Fertilizer-chain product benchmarks at a glance

Benchmark (FAR Annex I no.)	Unit of production	Gases in boundary	2021–25 value [all./t]	2026–30 value [all./t]	Carbon leakage	CBAM good
Nitric acid (39)	t HNO ₃ , 100 % purity	CO ₂ + N ₂ O	0.230	0.151	Yes → CLEF 1	Yes
Adipic acid (40)	t dry purified adipic acid	CO ₂ + N ₂ O	2.12	1.40	Yes → CLEF 1	No
Ammonia (41)	t NH ₃ , saleable net, 100 %	CO ₂	1.570	1.522	Yes → CLEF 1	Yes
Soda ash (52)	t Na ₂ CO ₃ , total gross prod.	CO ₂	0.753	1.122	Yes → CLEF 1	No

2026–2030: values per Impl. Reg. (EU) 2026/1412 (C(2026) 4372, 26.6.2026; data 2021–22). Heat benchmark: 31.2 · fuel benchmark: 28.1 allowances/TJ. Soda ash reflects the amended FAR Annex I definitions (Del. Reg. (EU) 2024/873) — always read a value together with its definition and period.

Read the CBAM column carefully: ammonia and nitric acid lose free allocation via the CBAM factor from 2026; adipic acid and soda ash keep CBAM factor = 1 (full benchmark allocation, subject to CLEF).



SECTION 3 · PRODUCT MAP

Which product belongs to which benchmark?

Product	Made by	Allocation basis	BM no.	Unit of production	CL list	CBAM good
Ammonia (incl. its H ₂)	SMR / gasification + Haber-Bosch	Product benchmark	41	t net saleable NH ₃ (100 %)	Yes	Yes
Nitric acid (incl. N ₂ O abatement)	Ostwald process	Product benchmark	39	t HNO ₃ at 100 %	Yes	Yes
Urea, AN, CAN, UAN, NPK / NP / NK	NH ₃ (+ HNO ₃ / CO ₂) + finishing	NO product BM → heat + fuel fallback	—	TJ of heat / fuel consumed (CL)	Yes	Yes (urea, mixed fert.)
Merchant hydrogen / syngas	stand-alone H ₂ or syngas plants	Product benchmark (own)	50 / 51	t H ₂ (100 %) / t syngas (47 % H ₂)	Yes	H ₂ : partly

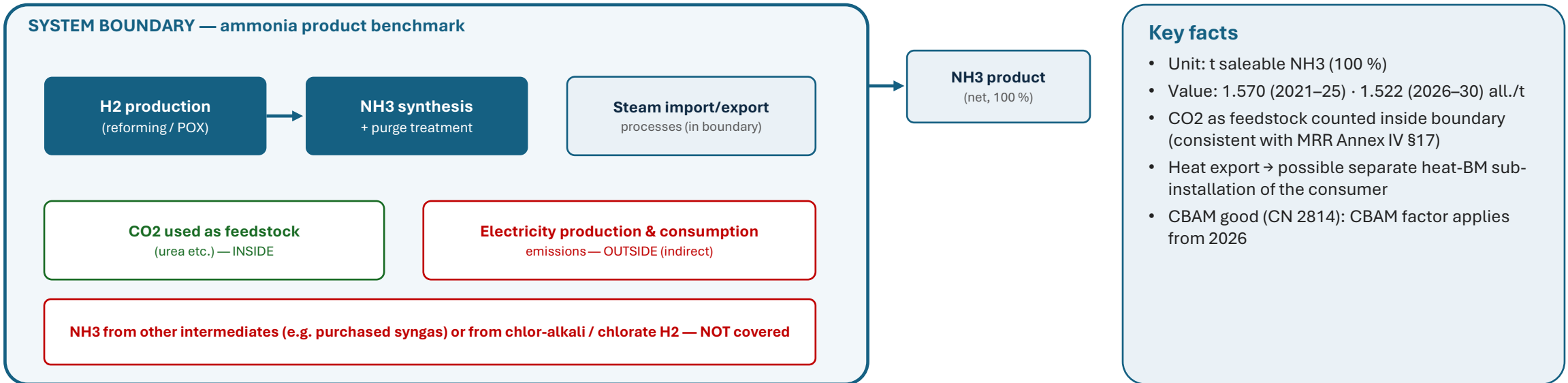
The rule of thumb: a product benchmark exists only where EU-wide comparable products exist. Fertilizer FINISHING (granulation, prilling, blending) is deliberately not benchmarked — it receives fallback allocation that follows the heat and fuel it consumes. Adipic acid (BM 40) and soda ash (BM 52) complete the family — both non-CBAM (factor 1).

Consequence for the BDR: an integrated complex reports one product-benchmark sub-installation per benchmarked product, plus fallback sub-installations for everything downstream — Section 4 shows how to cut them.



SECTION 3 · BENCHMARK 41

Ammonia benchmark — boundaries and special features



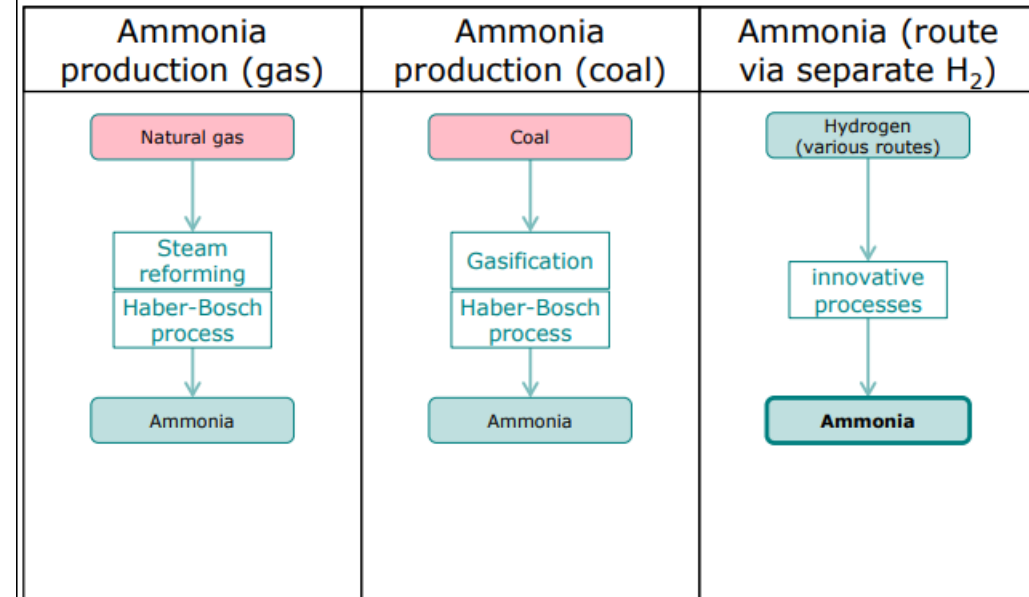
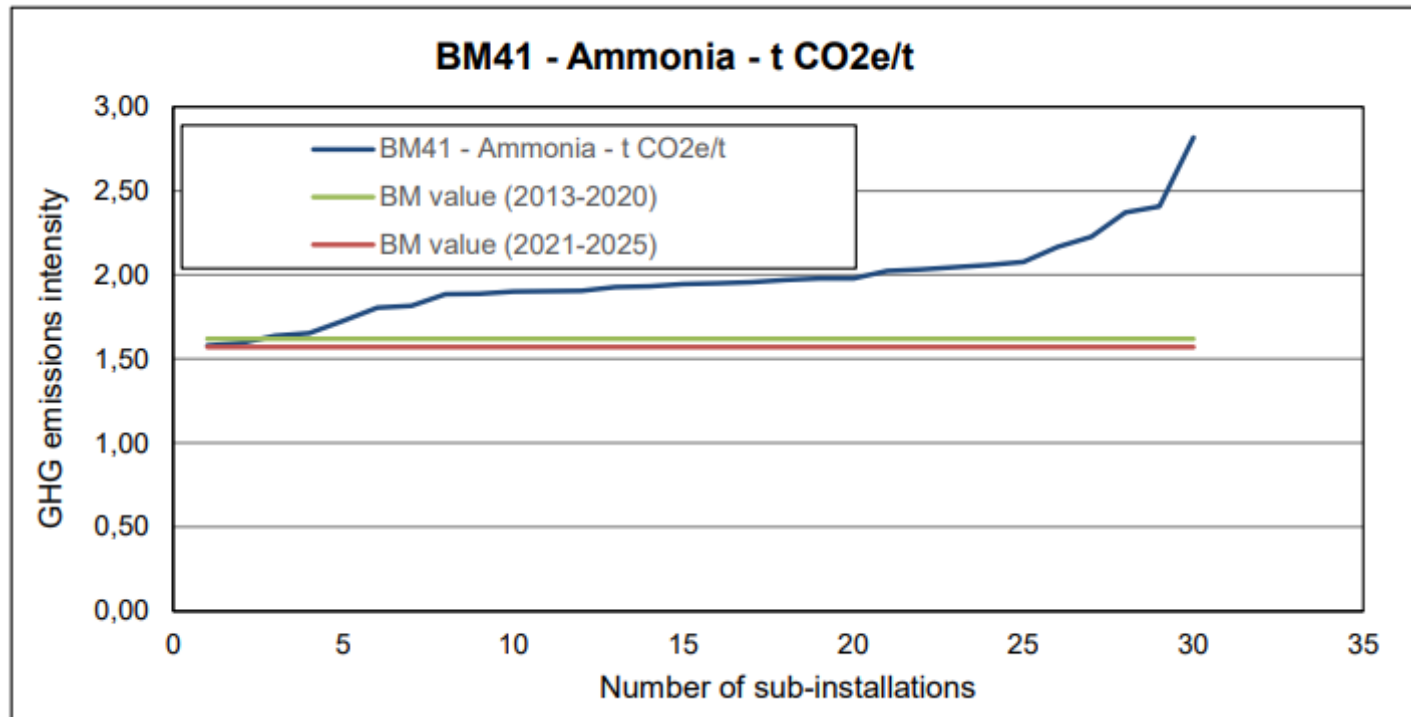
Boundary quote (FAR Annex I): “All processes directly or indirectly linked to the production of the ammonia and the intermediate product hydrogen are included... For the purpose of data collection, the total electricity consumption within the system boundaries shall be considered.”

FAR (EU) 2019/331 Annex I (benchmark 41) · GD9 §41 · Impl. Reg. (EU) 2021/447; 2026–30: Impl. Reg. (EU) 2026/1412



SECTION 3 · BENCHMARK 41 — THE CURVE

Ammonia — reading the benchmark curve



HOW TO READ THIS CURVE

- Each point = one ammonia sub-installation, ranked by GHG intensity (t CO₂e/t NH₃, boundary emissions incl. feedstock CO₂)
- Average of the 10 % most efficient (flat left tail) sets the value: 1.570 for 2021–25 (phase 3: 1.619)
- A FLAT curve: steam reforming is mature — 35 EU sub-installations cluster near the thermodynamic optimum; median 1.948
- Plant at the median buys ≈ 0.4 EUA/t at market — and from 2026 the CBAM factor cuts the free share further

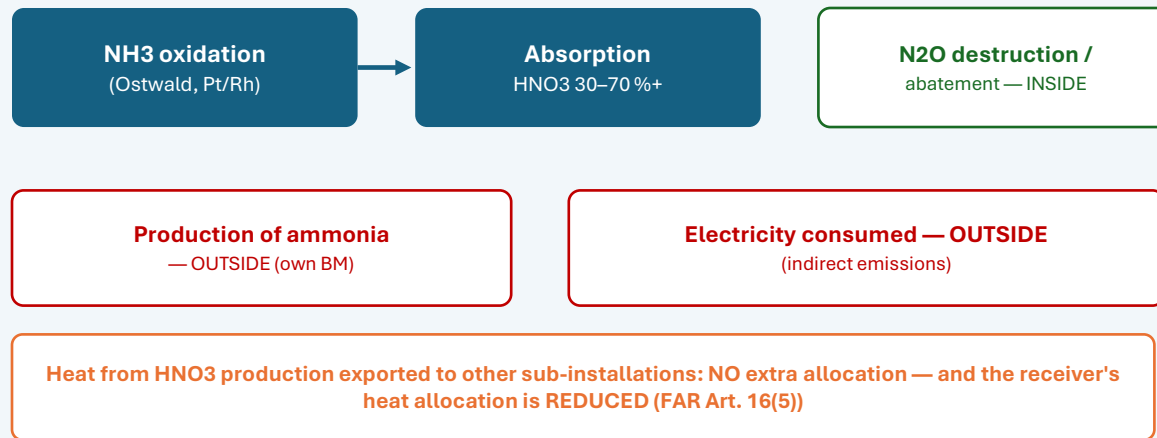
Route figure (top right): the H₂ route decides where a plant lands on this curve.



SECTION 3 · BENCHMARK 39

Nitric acid benchmark — N2O inside, ammonia outside, heat penalised

SYSTEM BOUNDARY — nitric acid product benchmark



Key facts

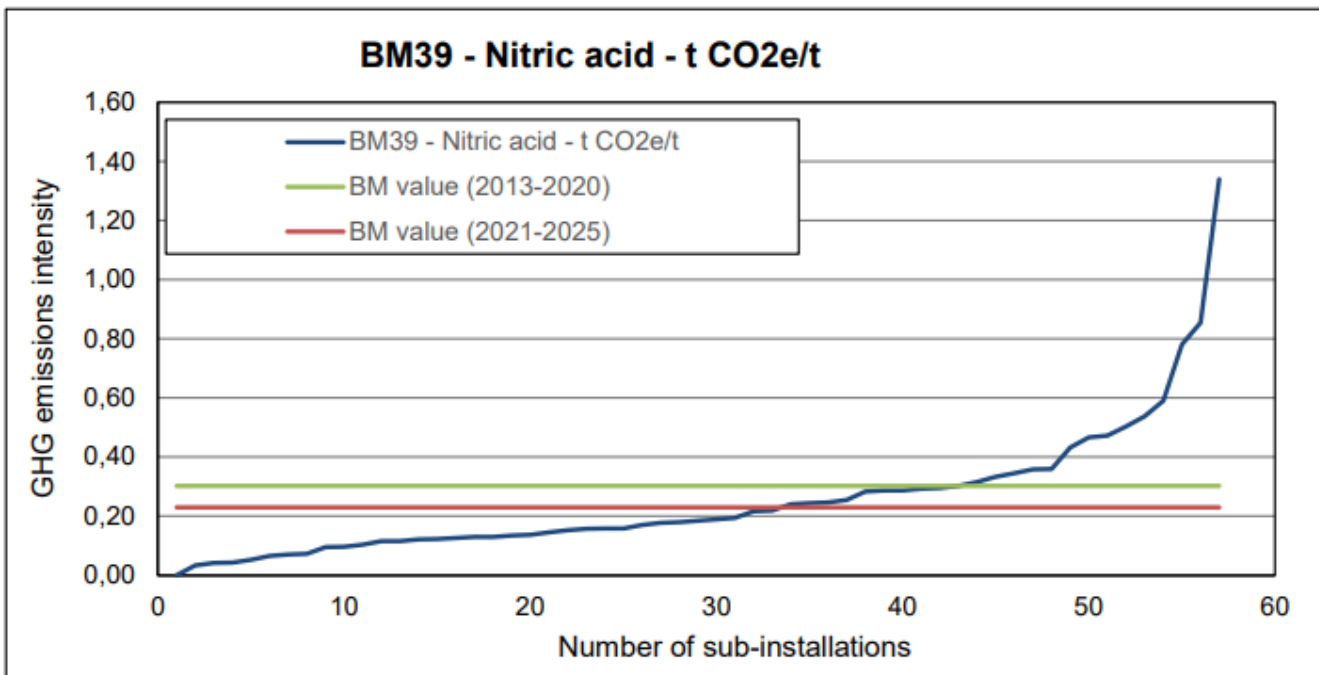
- Unit: t HNO3 at 100 % (divide by concentration!)
- Value: 0.230 (2021–25) · 0.151 (2026–30) all./t
- Covers CO2 + N2O (CEMS data feed HAL-period emissions)
- CBAM good (CN 2808 00 00)
- Special provision: exported measurable heat non-eligible

Art. 16(5) FAR mechanics: Reduction of receiver's preliminary allocation = $BM_{\text{heat}} \times HAL_{\text{heat-from-nitric-acid}}$. Rationale: the N2O-heavy benchmark already remunerates the whole process including its exothermic heat; paying the heat again at the receiving sub-installation would double-fund it.

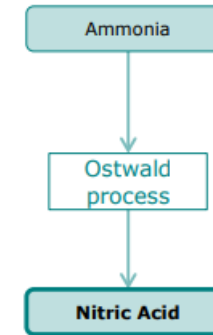


SECTION 3 · BENCHMARK 39 — THE CURVE

Nitric acid — the abatement cliff in one picture



Nitric acid production



HOW TO READ THIS CURVE

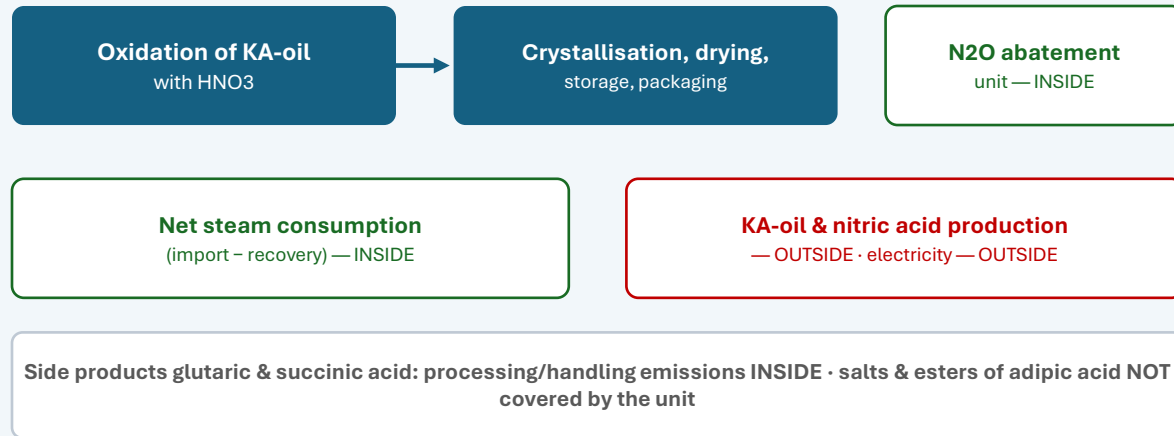
- 57 sub-installations ranked by t CO₂e/t HNO₃ (CO₂ + N₂O)
- Value 0.230 (2021–25) = average of the 10 % best; phase 3: 0.302
- Median (0.184) is BELOW the benchmark — most plants now run modern N₂O abatement
- The steep right tail = lines with weak or no tertiary abatement, up to ≈ 1.4 t CO₂e/t
- Clearest EU example of benchmark-driven abatement investment — falls further to 0.151 for 2026–30



SECTION 3 · BENCHMARK 40

Adipic acid benchmark — the N2O heavyweight (not a CBAM good)

SYSTEM BOUNDARY — adipic acid product benchmark



Key facts

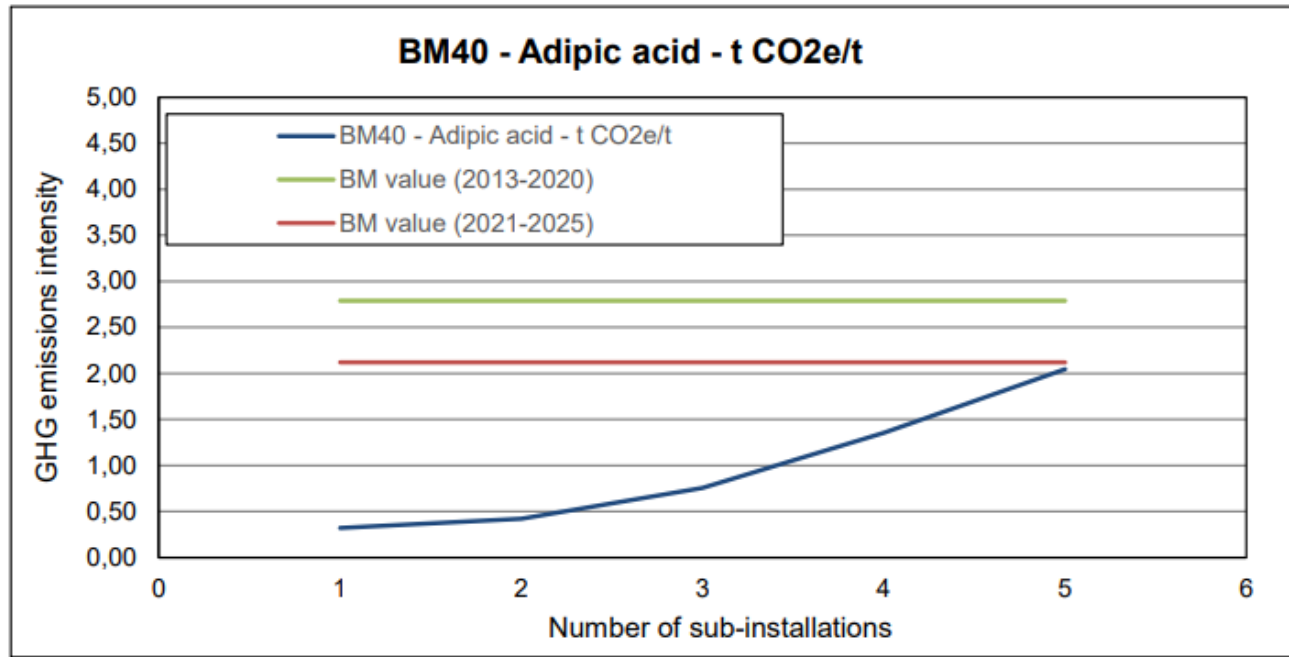
- Unit: t dry purified adipic acid (silos / big-bags)
- Value: 2.12 (2021–25) · 1.40 (2026–30) all./t
- CO2 + N2O in boundary; hybrid MRV regime (CEMS + mass balance)
- NOT a CBAM good → CBAM factor = 1
- Heat export eligible under heat BM (GD6 rules)

Why the highest benchmark of the four: stoichiometric N2O co-production (~0.3 t N2O/t before abatement ≈ 80–90 t CO2e/t unabated at GWP 265) means even the best abated plants carry material residual N2O — hence 2.12 allowances per tonne.



SECTION 3 · BENCHMARK 40 — THE CURVE

Adipic acid — five installations, one N2O story



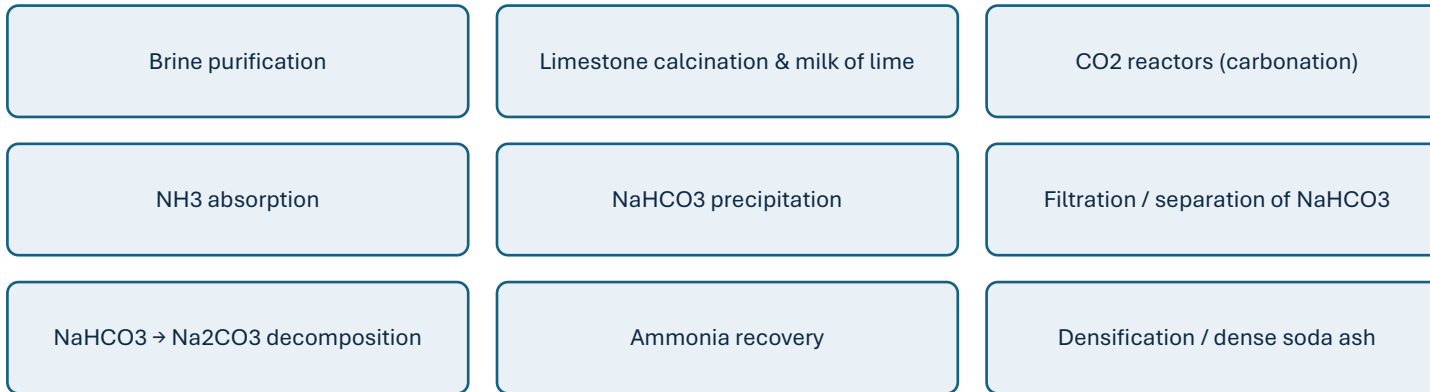
HOW TO READ THIS CURVE

- Only 5 EU sub-installations use this benchmark — the smallest population of the four (confidentiality limits published detail)
- Value 2.12 (2021–25) = average of the 10 % best; phase 3: 2.79 — the calculated update rate (–9.84 %/yr) hit the –1.6 %/yr cap
- Median of all plants: 0.76 t CO₂e/t — abated plants sit far below the value; unabated events dominate the right end
- Residual N₂O after abatement keeps this the highest of the four fertilizer-chain benchmarks
- Not a CBAM good: allocation continues at CLEF 1 — value falls to 1.40 for 2026–30



SECTION 3 · BENCHMARK 52

Soda ash benchmark — nine process units, one boundary



Key facts

- Unit: t soda ash, TOTAL GROSS production
- Excluded: dense soda ash by-product of caprolactam networks
- Value: 0.753 (2021–25) · 1.122 (2026–30, revised definition) all./t
- CO₂ only · electricity emissions outside
- NOT a CBAM good → CBAM factor = 1
- Annex I activity: production of soda ash and NaHCO₃

Boundary formula (FAR Annex I): “all processes directly or indirectly linked to the process units” listed above are *included*. Emissions of consumed electricity are excluded; exported measurable heat is not covered but may be eligible under heat-benchmark rules (GD6).

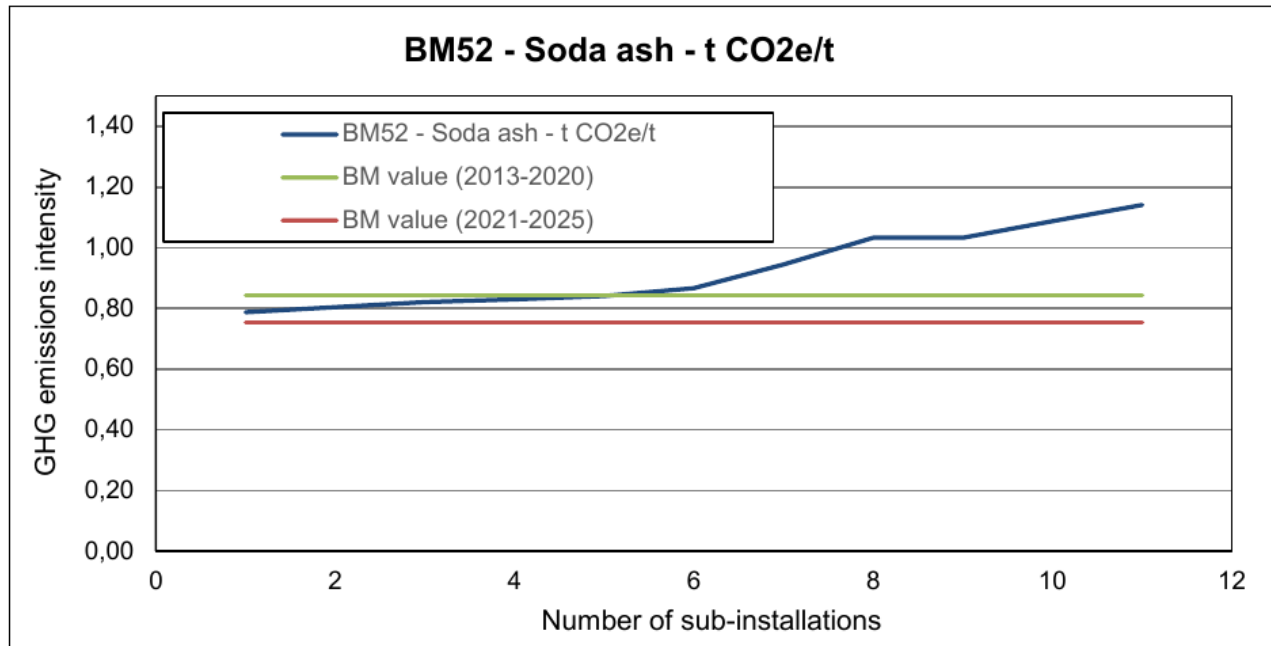
Sub-installation practice: the CHP / boiler house serving the Solvay units belongs **INSIDE** the product benchmark to the extent its heat feeds the nine units — only heat to other consumers forms a separate sub-installation.

FAR (EU) 2019/331 Annex I (benchmark 52) · GD9 §52 · Impl. Reg. (EU) 2021/447; 2026–30: Impl. Reg. (EU) 2026/1412



SECTION 3 · BENCHMARK 52 — THE CURVE

Soda ash — a tight curve about to be redefined



HOW TO READ THIS CURVE

- 12 sub-installations ranked by t CO₂e/t soda ash (gross production)
- Value 0.753 (2021–25) = average of the 10 % best; phase 3: 0.843; median 0.866 — a tight band, Solvay technology is mature
- Our case study plant (≈ 0.8 t CO₂/t) sits mid-curve — free allocation covers ≈ 94 % of its attributed emissions
- For 2026–30 the value RISES to 1.122 — the amended Annex I definition (Del. Reg. (EU) 2024/873) adds the CO₂ bound in the product to the benchmark scope, not worse performance
- Never read a benchmark value without its definition and period



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SECTION

4

System boundaries & sub-installations

How an installation is cut into sub-installations, and how emissions and energy flows are attributed between products

In this section

- Installation boundary vs sub-installation vs benchmark boundary
- The strict hierarchy: product benchmark → heat → fuel → process emissions
- Included and excluded processes at each benchmark boundary
- Interactions between sub-installations: heat, CO₂, intermediate products
- Graphical boundary examples for an integrated fertilizer complex

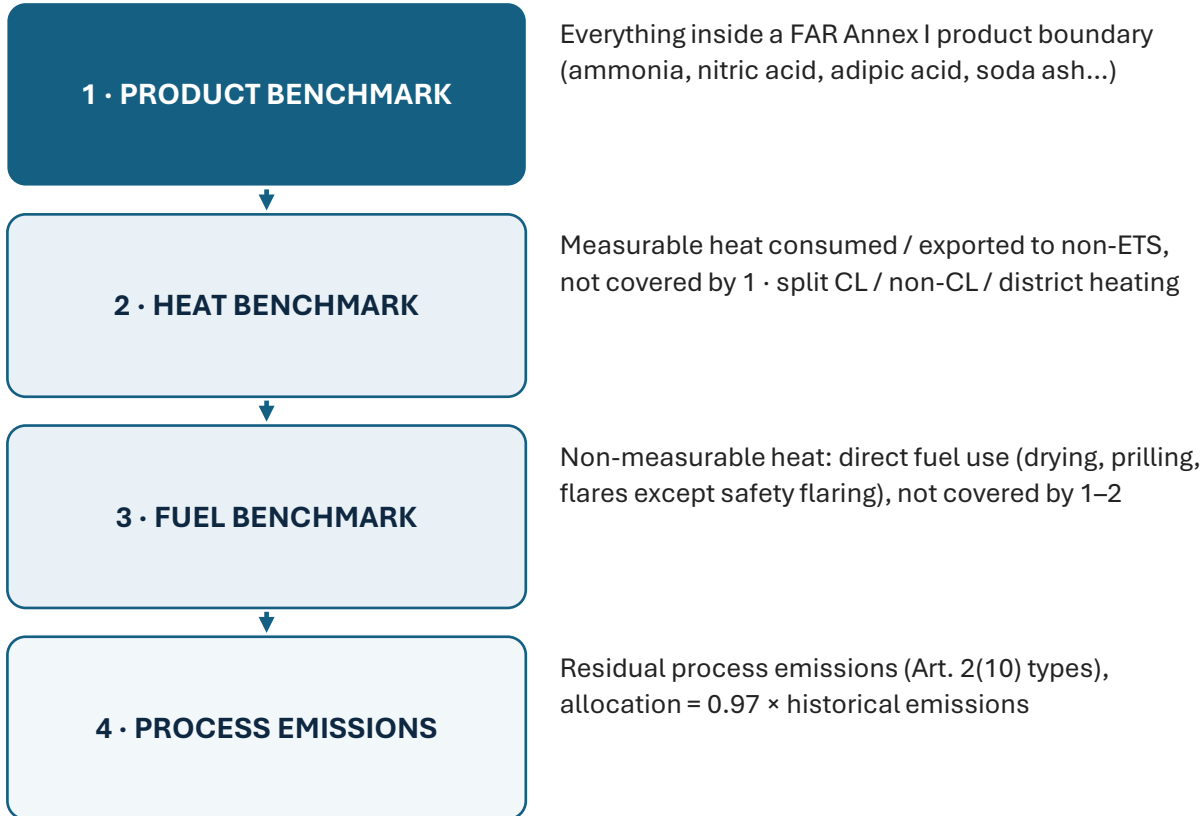
Primary legal sources

- Delegated Reg. (EU) 2019/331 (FAR), Art. 2–10, Annex I–IV, VI–VII
- Impl. Reg. (EU) 2019/1842 (ALC)
- GD9 (2024) + GD2 (installation guidance), GD3 (data collection)



SECTION 4 · THE SPLITTING RULE

Sub-installation hierarchy — strictly in this order (FAR Art. 10)



Golden rules

- Mutually exclusive, jointly exhaustive — every emission in exactly one sub-installation
- Physical units can be shared: one boiler may serve several sub-installations (attribute by measured heat)
- CL status split: separate heat/fuel sub-installations for carbon-leakage vs non-CL products
- Electricity: never allocated via these sub-installations (indirect; national compensation only)
- Safety flaring → heat benchmark treatment excluded; process flaring → fuel benchmark

FAR (EU) 2019/331 Art. 2(10), Art. 10, Annex I · GD2/GD3 · process emissions factor 0.97: FAR Art. 24 practice



SECTION 4 · THREE BOUNDARIES

Installation boundary vs sub-installation vs benchmark boundary

Installation boundary — the MRV world

- Set by the GHG permit: all Annex I activities plus directly associated activities
- Answers: what does the site EMIT? — verified every year in the AER
- One boundary; transferred CO₂ crosses it only under Art. 48–49a rules
- Same boundary for category, tiers and verification duties
- Source: Directive Annex I + MRR

Sub-installations & benchmark boundaries — the FAR world

- **Sub-installations cut the installation into allocation units:** product benchmark parts first, then heat, fuel, process emissions — mutually exclusive, jointly exhaustive
- **Each product benchmark has a FIXED system boundary (FAR Annex I):** "all processes directly or indirectly linked to production" — the same list for every plant in Europe
- **Included at ammonia:** reforming, shift, CO₂ removal, synthesis, purge treatment, own steam systems — and the H₂ intermediate
- **Excluded everywhere:** electricity-related (indirect) emissions; inputs with their own benchmark (NH₃ into HNO₃); downstream products (urea is outside BM 41)
- **Why fixed boundaries:** comparability — ranking installations only makes sense if every plant counts exactly the same processes

One site, two worlds: the MRV boundary decides what is reported and surrendered; the FAR boundaries decide what is allocated for free. **They meet in the Monitoring Methodology Plan (MMP)**, which maps every tonne of CO₂ and every TJ of heat to exactly one sub-installation.

FAR (EU) 2019/331 Art. 2, 10, Annex I · MRR (EU) 2018/2066 · GD2 · GD9 §§39–41, 52



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SECTION

5

Worked calculation

In this section

- Integrated fertilizer complex — sub-installation map
- Old world vs new world — what the producer must now buy

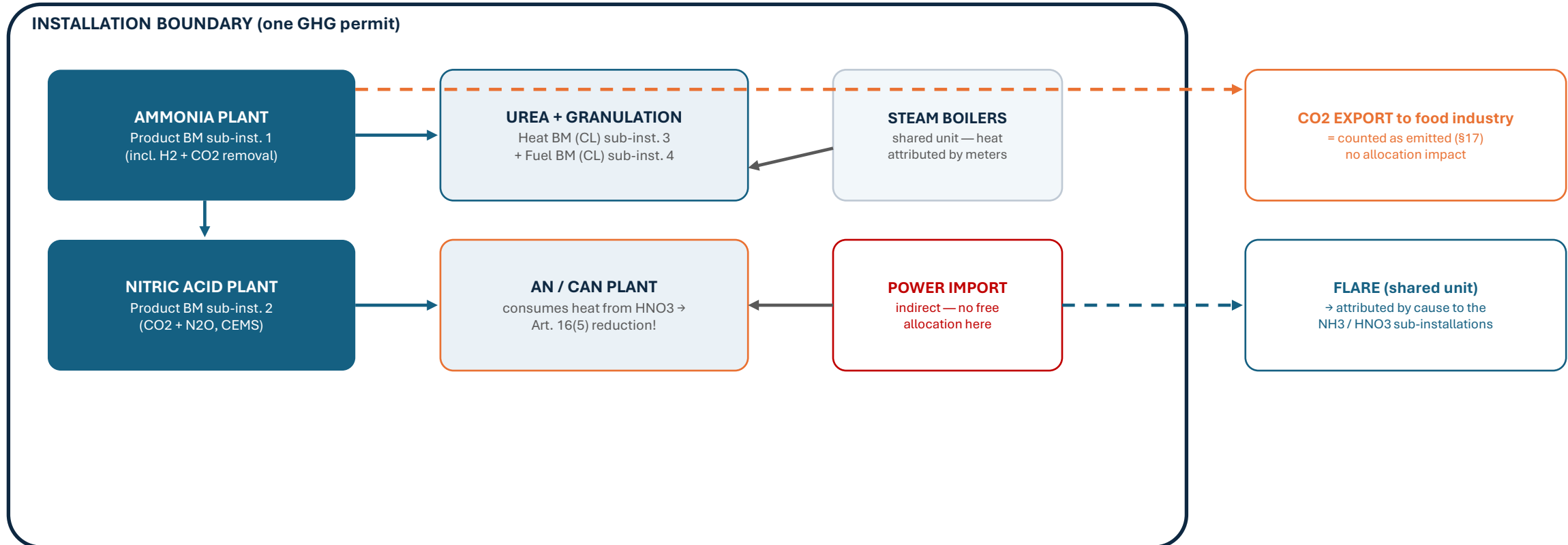
Primary legal sources

- FAR (EU) 2019/331 Art. 16 · Directive 2003/87/EC Art. 10a(1a), 10a(5)
- Impl. Reg. (EU) 2021/447 (BM values used here)
- Impl. Reg. (EU) 2026/1412 (insert 2026–30 values in live work)



SECTION 4 · WORKED BOUNDARY MAP

Integrated fertilizer complex — sub-installation map



One installation → 4 sub-installations: 2 product BM (NH₃, HNO₃) · 1 heat BM (CL) · 1 fuel BM (CL) — plus the Art. 16(5) correction on the heat flowing from HNO₃ to AN.

FAR (EU) 2019/331 Art. 10, 16(5), 21 · GD2 §Installation splitting · GD6 (cross-boundary heat)



SECTION 4 · INTERACTIONS

Flows between sub-installations — and who gets the allocation

Flow between units	Rule that applies	Allocation consequence
Steam: nitric acid → AN / finishing units	FAR Art. 16(5) — this heat is already paid inside BM 39	receiver's heat allocation REDUCED by heat-BM × that heat
Steam: shared boilers → several consumers	attribute by steam metering per the MMP (FAR Annex VII)	each consuming sub-installation claims only its measured share
CO2: ammonia plant → urea plant	MRR Annex IV §17 — counted as emitted at the NH3 plant	no allocation effect; the urea unit gets heat/fuel fallback only
NH3: ammonia plant → nitric acid plant	NH3 is outside the BM 39 boundary (it has its own benchmark)	no double allocation — each product is paid once, in its own BM
Heat imported from a non-ETS supplier	FAR Art. 21 special rules for cross-boundary heat	allocation possible at the consumer, with corrections
Carbonate additives / residual process chemistry	process emissions sub-installation (FAR Art. 2(10))	0.97 × historical process emissions

The attribution principle: every tonne of CO2 and every TJ of heat must land in exactly ONE sub-installation. Where a physical unit serves several (boilers, flares), metering plus MMP attribution rules divide it — nothing is counted twice, nothing is lost. Getting these interactions right is where allocation projects are won or lost.

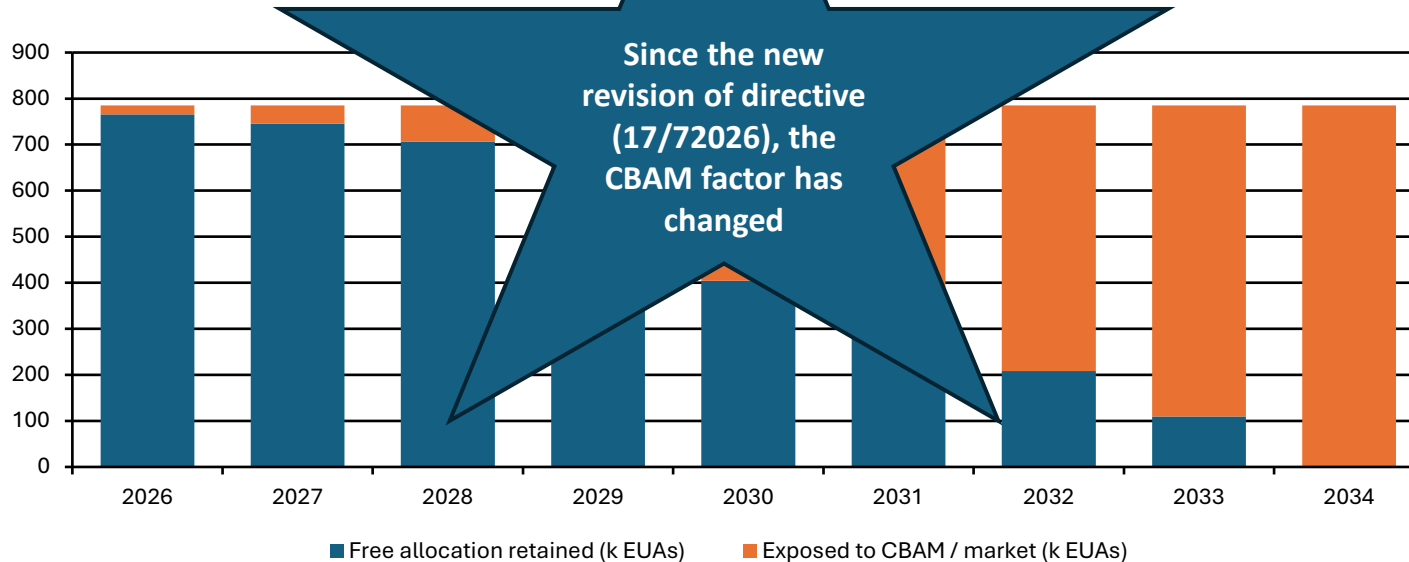
FAR (EU) 2019/331 Art. 10, 16(5), 21, Annex VII · GD6 (cross-boundary heat) · MRR Annex IV §17



SECTION 5 · STEP 4 — THE CBAM FACTOR

CBAM goods lose free allocation on a fixed schedule

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
CBAM factor	97.5 %	90 %	77.5 %	51.5 %	39 %	26.5 %	14 %	0 %	0 %
Allocation (k EUAs)	765	765	707	608	404	306	208	110	0



Read the cliff

- Gentle start (–2.5 pp/yr to 2028), steep middle (–26 pp in 2030), zero in 2034
- Mirror image: importers surrender CBAM certificates for the SAME phased-in share
- Applies only to CBAM goods: ammonia & nitric acid here — NOT soda ash / adipic acid
- Formula: Final = BM × HAL × CLEF × CBAM factor

Directive 2003/87/EC Art. 10a(1a) (schedule) · Reg. (EU) 2023/956 Art. 31 · FAR Art. 16a (as amended by Del. Reg. 2024/873)



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SECTION

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Urea & mixed fertilizers — the downstream chain

How NH₃, CO₂ and HNO₃ become urea, AN, CAN, UAN and NPK — and how the EU ETS and CBAM each see the downstream steps

In this section

- Urea synthesis: chemistry, process flow and CO₂ consumption
- Mixed fertilizers: AN, CAN, UAN and NPK routes and their emissions
- Monitoring considerations for finishing plants: dryers, heat, additives
- The downstream asymmetry: fallback allocation in the ETS — full goods under CBAM

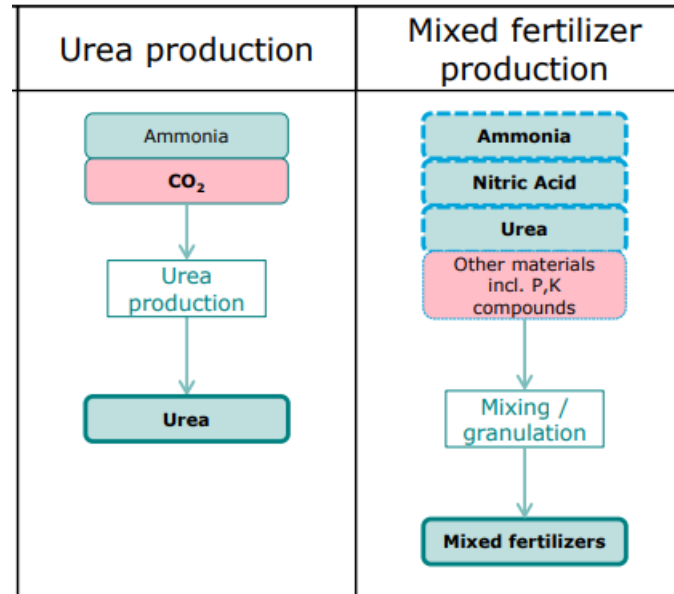
Primary legal sources

- MRR (EU) 2018/2066, Annex IV §17 · FAR fallback allocation rules
- CBAM Guidance for Importers §5.5.3 · IR (EU) 2025/2547 Annex II §§3.9–3.10
- Reg. (EU) 2023/956 Annex I (urea and mixed fertilizers)



SECTION 6 · THE TWO DOWNSTREAM PROCESSES

Urea and mixed fertilizers — the production systems CBAM sees





SECTION 6 · UREA

Urea — chemistry, process flow and CO2 balance

Step	Chemistry / operation	CO2 & monitoring view
1 · CO2 supply from the NH3 plant's removal unit	pure CO2 compressed to ~150 bar	counted at the NH3 plant (Annex IV §17)
2 · Carbamate formation (exothermic)	$2 \text{ NH}_3 + \text{CO}_2 \rightarrow \text{NH}_2\text{COONH}_4$	consumes 0.733 t CO2 / t urea
3 · Dehydration to urea (endothermic)	$\text{NH}_2\text{COONH}_4 \rightarrow \text{CO}(\text{NH}_2)_2 + \text{H}_2\text{O}$	steam → heat-BM sub-installation (CL)
4 · Recycle of unconverted NH3 / CO2	stripping and carbamate recycle loops	internal loop — no source stream
5 · Evaporation + prilling / granulation	melt concentrated, shaped, dried	fired dryers → fuel-BM sub-installation (CL)
6 · Product leaves the site (urea, 46 % N)	CO2 is re-released on use in the field	ETS: no deduction · CBAM: CO2 → urea's SEE

Numbers to remember: 1 t urea binds 0.733 t CO2 and needs ~0.57 t NH3. A 600 kt/yr urea line consumes ≈ 440 kt CO2/yr — roughly the process-CO2 output of its ammonia plant. ETS and CBAM treat this CO2 differently: the ETS counts it at the NH3 plant (Annex IV §17); CBAM carries it into urea's embedded emissions (IR 2025/2547 Annex II §3.9). Never mix the two logics.

MRR (EU) 2018/2066 Annex IV §17 · IR (EU) 2025/2547 Annex II §3.9 · CBAM Guidance for Importers §5.5.3.3



SECTION 6 · MIXED FERTILIZERS

AN, CAN, UAN, NPK — routes, emissions, monitoring

Product / route	Process	Emissions & monitoring view
AN — ammonium nitrate	$\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3$, evaporation, prilling	no process CO ₂ ; dryer fuel CO ₂ ; N ₂ O sits upstream in HNO ₃
CAN — calcium ammonium nitrate	AN melt + ground limestone / dolomite filler	filler NOT calcined → normally no carbonate CO ₂
UAN solution (32 % N)	urea + AN dissolved together ~1:1	inherits urea's CO ₂ and AN's HNO ₃ -N ₂ O via precursors
NPK — mixed-acid or nitrophosphate route	phosphate rock + acids + NH ₃ ; K salts; granulation	dryer fuel CO ₂ ; possible carbonate CO ₂ from the rock
Blending / bulk mixing only	physical mixing of finished fertilizers	outside the ETS unless combustion > 20 MW
CBAM view of all of the above	CN 3102 / 3105, KNO ₃ — kg-N unit from 2026	embedded = own fuel + electricity + precursor SEE

The downstream asymmetry — say it twice: these products have NO product benchmark (fallback heat/fuel allocation, CL via NACE 20.15) — yet they ARE CBAM goods. The finishing plant's own emissions are small; the carbon story of an NPK is written almost entirely in its precursors: the ammonia route and the nitric acid N₂O abatement.

CBAM Guidance for Importers §5.5.3.4 · IR (EU) 2025/2547 Annex II §3.10 · FAR (EU) 2019/331 fallback rules



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SECTION

7

CBAM and fertilizers

Embedded emissions, calculation methods, default values, and the importer's obligations in the definitive period

In this section

- Which fertilizer goods are covered (CN codes) — and which are not
- Embedded emissions: direct, indirect, precursors; the new functional unit
- Actual values vs default values — the definitive-period rulebook
- Complete reporting example: NPK 15-15-15
- Interaction with EU ETS free allocation and the 2026–2034 phase-out

Primary legal sources

- Reg. (EU) 2023/956 (CBAM), as amended by Reg. (EU) 2025/2083
- Impl. Reg. (EU) 2025/2547 (definitive-period calculation methods)
- CBAM Guidance for Importers (transitional-period concepts)



SECTION 7 · SCOPE

Which fertilizer goods are CBAM goods (Annex I, Reg. 2023/956)

Aggregated goods category	CN codes	Notes	Relevant GHG
Nitric acid	2808 00 00	incl. sulphonitric acids	CO ₂ + N ₂ O
Urea	3102 10	whether or not in aqueous solution	CO ₂
Ammonia	2814	anhydrous or aqueous solution	CO ₂
Mixed fertilizers	2834 21 00 · 3102 (excl. 3102 10) · 3105 (excl. 3105 60 00)	K-nitrates, N-fertilizers, NPK/NP/NK	CO ₂ + N ₂ O
NOT covered	3105 60 00 (PK), 3104 (potassic), phosphates 3103	no significant N-related embedded emissions	—

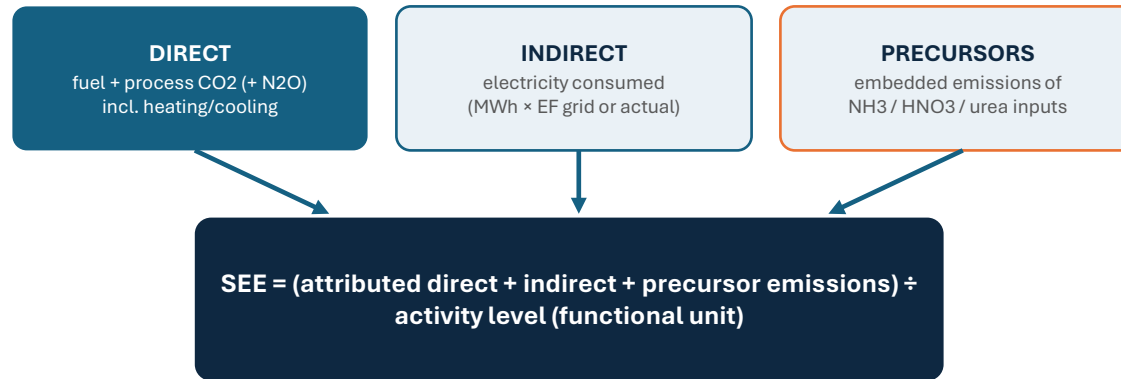
Remember the asymmetry: urea, AN, CAN, NPK are CBAM goods but have NO EU ETS product benchmark (fallback allocation only); adipic acid and soda ash are ETS-benchmarked but NOT CBAM goods. **De-minimis (2025 amendment):** importers of ≤ 50 t/year of covered goods (cumulative mass, all CBAM goods except electricity & hydrogen) are exempt — removing ~90 % of importers, keeping ~99 % of emissions.



SECTION 7 · CONCEPT

Embedded emissions — direct + indirect + precursors

PRODUCTION PROCESS SYSTEM BOUNDARY (third-country installation)



Functional unit (definitive period)

- **CN 2808, 2814, 3105: kg of NITROGEN contained (IR 2025/2547 Art. 4(4))**
- **Urea & other CN:** CN supplementary units
- N content recorded by form: ammonium (NH₄⁺), nitrate (NO₃⁻), urea, other (per Reg. 2019/1009)

EU ETS mirror by design: monitoring at installation level → attribution to production processes → division by output (IR 2025/2547 Art. 4–8, Annex II–III) — methodologically the MRR transplanted. Complex goods = simple goods + precursor embedded emissions (Art. 15–16: actual or default precursor values).

Reg. (EU) 2023/956 Annex IV · Impl. Reg. (EU) 2025/2547 Art. 4–8, 15–16, Annex II §§3.7–3.10, Annex III



SECTION 7 · DETERMINING THE NUMBERS

Actual values vs default values

ACTUAL values (preferred)

- Installation-level monitoring per IR 2025/2547 Annex II — EU ETS methodology (calculation / measurement)
- Reporting period: typically the calendar year preceding import; data via the CBAM Registry (operator portal)
- Verified by accredited verifier; declarant uses verified SEE per installation & goods category
- Precursors: actual SEE from the precursor's installation, or default

DEFAULT values (fallback)

- Set per third country + goods category where reliable data exist; otherwise: average of the X % worst-performing EU ETS installations, with mark-up
- Indirect: default grid emission factor of the origin country (or actual under PPA/direct-line conditions)
- No verification needed — but deliberately conservative: paying the default is usually MORE expensive than proving actuals
- Alternative defaults possible if formally adopted and published by the Commission

Consulting play: helping third-country fertilizer plants build EU-ETS-grade MRV to replace defaults with actuals is the single largest CBAM value lever.

Reg. (EU) 2023/956 Annex IV §§4–5 · Impl. Reg. (EU) 2025/2547 Art. 15–16, recitals 19–22, Annex II



Interactive Q&A



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Fertilizers – Day 5

Primary sources cited in this storyboard

- EU ETS Directive 2003/87/EC (consolidated 01.03.2024)
- Free Allocation Regulation (EU) 2019/331 (cons. 01.01.2024) — Annex I, Annex IV [ETS/]
- Free Allocation Guidance GD9 — sector-specific guidance, Fertilizers
- Supporting guidance: GD3, GD4, GD5, GD6, GD8 [ETS/]
- CBAM Implementing Reg (EU) 2025/2620
- CBAM Reg (EU) 2023/956 and 2025/2621 (default values) [CBAM/]
- Accreditation & Verification Reg (EU) 2018/2067 (AVR) [MRV/]