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PBL Netherlands Environmental Assessment Agency

UPDATE REPORT:

DECARBONISATION OPTIONS FOR SALT AND CHLOR-ALKALI PRODUCTION BY NOBIAN INDUSTRIAL CHEMICALS B.V.

Update based on original MIDDEN reports by E.L.J. Scherpbier and H.C. Eerens published on 31 March 2021 and 10 June 2021.

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Date of update: 25 September 2025

MIDDEN

Manufacturing Industry Decarbonisation Data Exchange Network

Colophon

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The Hague, 2025
PBL publication number: 5825

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Acknowledgements
Special thanks to Dick van Dam, Robert Koelemeijer (both PBL) and Nobian Industrial Chemicals B.V..

MIDDEN project coordination and responsibility
The MIDDEN project (Manufacturing Industry Decarbonisation Data Exchange Network) was initiated and is also coordinated and funded by PBL and TNO. The project aims to support industry, policymakers, analysts, and the energy sector in their common efforts to achieve deep decarbonisation. Correspondence regarding the project may be addressed to: L. van Geene (PBL), Laura.vanGeene@pbl.nl.

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This report has been reviewed by Robert Koelemeijer and Dick van Dam (both PBL). A non-final version of this report was reviewed by Nobian Industrial Chemicals B.V. PBL is responsible for the content of the report. The decarbonisation options and parameters are explicitly **not verified** by Nobian Industrial Chemicals B.V..

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1 Introduction

The Dutch government aims to make legally binding, tailor-made agreements with the most energy-intensive industrial plants in the Netherlands in order to support their transition to decarbonised production processes. In July 2025, the Dutch government shifted its focus to industrial plants that have concrete plans for the reduction of greenhouse gas emissions in 2030 that can benefit from a tailor-made approach, and halted the discussion with several other industrial plants (Ministry of Climate & Green Growth 2025). The process to arrive at a tailor-made agreement starts with two preceding steps: (1) a non-binding agreement, or a so-called Expression of Principles (EoP), followed (2) by a more detailed, but still non-binding, Joint Letter of Intent (JLoI).

Nobian Industrial Chemicals B.V. is the first energy-intensive Dutch industrial company to agree on a binding tailor-made agreement with the Dutch government to accelerate its decarbonisation process. Nobian Industrial Chemicals B.V. is the most important manufacturer of salt and chlor-alkali products in the Netherlands, with factories in Delfzijl, Hengelo, and Rotterdam. Backed by the financial and legislative support provided by the tailor-made agreement, it is expected that Nobian can achieve nearly climate-neutral production in 2030, which is ten years earlier than previously aimed for by the company (Rijksoverheid 2024). According to the agreement, Nobian will invest €642 million in decarbonisation projects. Nobian will also receive a maximum of €185 million in subsidies from the Dutch government between 2025 and 2029 (Rijksoverheid 2024).

Decarbonisation options for the Dutch salt and chlor-alkali industries have already been discussed in two separate MIDDEN reports by Scherpbier & Eerens (2021a, 2021b). This update report describes the definitive decarbonisation options chosen by Nobian in the tailor-made agreement with the Dutch government. No new options are discussed for the other manufacturers of salt and chlor-alkali products in the Netherlands.

The update report is structured as follows: Chapter 2 shows updated statistics of the current salt and chlor-alkali production by Nobian in the Netherlands and the CO_2-emissions driven by the current production process. Chapter 3 provides an overview of the decarbonisation options agreed upon in the tailor-made agreement, including the technical specifications and estimated emission reduction of these options.

2 Production by Nobian

The production and CO_2-emissions of Nobian's salt factories in Delfzijl and Hengelo, and those of the electrolysis plants in Delfzijl and Rotterdam, have been reviewed and updated in the MIDDEN database. The original MIDDEN reports by Scherpbier & Eerens (2021a, 2021b) used 2016 as the base year for their analyses.

2.1 Salt production

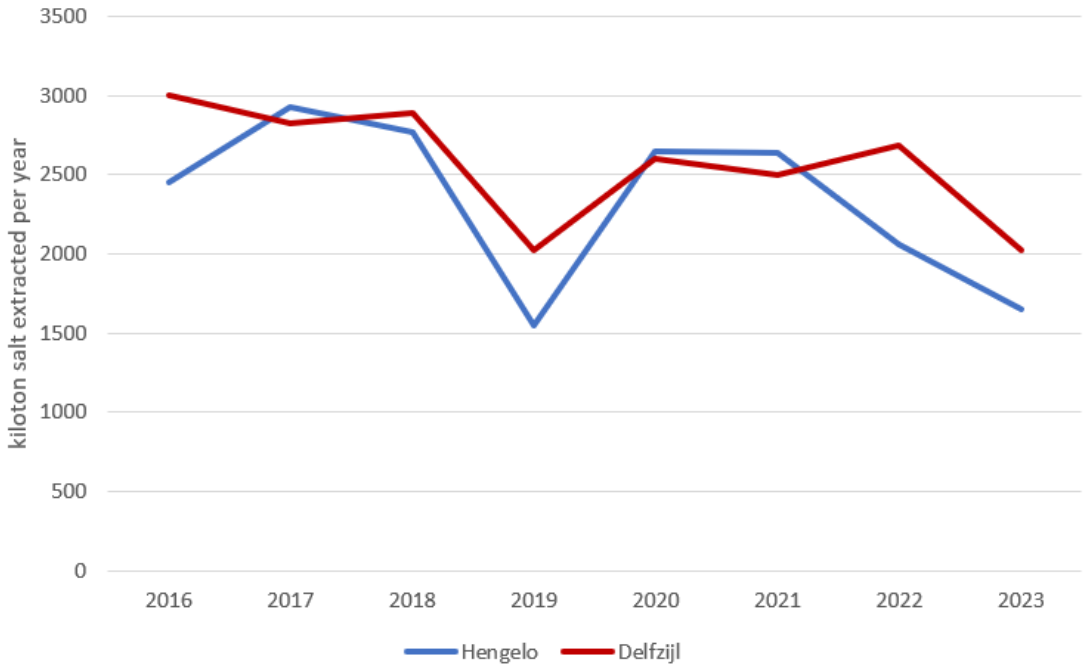
Based on official reporting about salt mining in the Netherlands in 2023, Nobian mined substantially less salt (NaCl) in 2023 at its various facilities than in 2016 as shown in Table 2.1 and Figure 2.1 (Ministry of Climate & Green Growth 2024). Almost 2000 kiloton less salt was extracted in 2023 due to lower demands for chlorine products (Ministry of Climate & Green Growth 2024; Lalkens 2024). The salt industry is of great importance for the Dutch chemical industry, as the majority of the salt extracted in the Netherlands is used as a feedstock for chlor-alkali electrolysis and other chemical processes (Bollen & van Bree, 2024).

Table 2.1
Salt extraction at Nobian's salt mines in 2016 and 2023.

Plant	**Rock salt extraction locations**	**Salt extracted 2016 [kt]** (Scherpbier & Eerens 2021a)	**Salt extracted 2023 [kt]** (Ministry of Climate & Green Growth 2024)	**Total extraction per plant in 2023 [kt]**
Nobian Hengelo	Twenthe-Rijn	1300	1225	**1652**
	Twenthe-Rijn Helmerzijde	320	2	
	Twenthe-Rijn (expansion)	830	315	
	Twenthe-Rijn Oude Maten[a]	-	110	
Nobian Delfzijl	Adolf van Nassau II	1400	1085	**2020**
	Adolf van Nassau II (expansion)	1600	935	
Total annual salt extraction		**5450**	**3672**	

a) This site was excluded in the original MIDDEN report by Scherpbier & Eerens (2021a) since Nobian did not mine any salt here in 2016 (Ministry of Economic Affairs 2017).

Figure 2.1
Salt extracted (kiloton per year) by Nobian between 2016 and 2023, aggregated per processing site (Ministry of Economic Affairs & Climate Policy 2018, 2019, 2020, 2021, 2022, 2023; Ministry of Climate & Green Growth 2024)



2.2 Chlor-alkali production

In 2023, the European chlorine sector performed at 60-70% of its total capacity due to declining chlorine demands. Nobian reported that its chlor-alkali plants performed at the upper end of that margin at around 70% of their capacity (Lalkens 2023). Table 2.2 shows an estimate of the chlor-alkali production in 2023. The chlor-alkali production in 2016 as reported by Scherpbier & Eerens (2021b) was scaled down to reflect the decreasing demands in 2023.

Table 2.2
The annual chlor-alkali production capacity at Nobian's electrolysis plants and their estimated production in 2023.

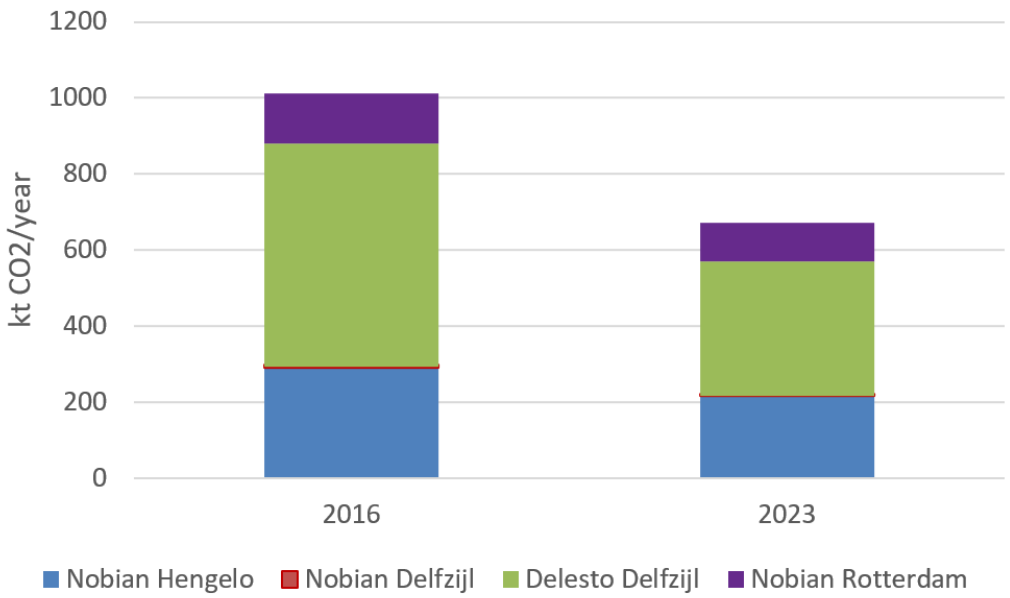
Plant	**Production capacity (2016) [kt/yr]** (Scherpbier & Eerens 2021b)			**Estimated production in 2023 [kt/yr]**		
	Chlorine	*Caustic soda*	*Hydrogen*	*Chlorine*	*Caustic soda*	*Hydrogen*
Nobian Botlek	640	700	18	450	490	12.5
Nobian Delfzijl	120	130	4	85	91	2,8

2.3 Current CO_2 emissions

Figure 2.2 shows the ETS emissions of Nobian's Dutch plants, including the Combined Heat Power plants (CHPs) Delesto 1 and 2 in Delfzijl. The Emissions Trading System (ETS) emissions of Nobian's operation in the Netherlands decreased between 2016 and 2023. As can be seen in the Figure, the most important contributors to Nobian's ETS emissions are its Hengelo plant (including their on-site CHP plant) and the Delesto facility in Delfzijl. Delesto 2 currently operates as a peak load electricity plant, while the Delesto 1 CHP plant produces the steam that is used in Nobian's salt production process (see Section 3.1). In 2023, Nobian produced significantly less salt than in 2016 and, therefore, required less steam from the Delesto 1 CHP and its CHP in Hengelo.

Still, a direct link between Nobian's lower production and the reduction of CO_2 emissions of Delesto Delfzijl and Nobian Hengelo in Figure 2.2 cannot be made for several reasons. First, the two CHP's are not Nobian's only source of steam, as both Nobian's locations also use steam that is provided by third parties, such as the energy from waste (EEW) plant and Eneco Biomass Energy Plant in Delfzijl (Rijksoverheid 2024) and the Twence municipal waste plant in Hengelo (Scherpbier & Eerens 2021a; Rijksoverheid 2024). Secondly, Delesto 1 also produces steam and electricity for other parties in the Delfzijl industry cluster (BBO 2024), although the details about this are not known. The Delesto 2 plant produces electricity solely for the grid.

Figure 2.2
EU ETS emissions of Nobian's Dutch plants, including Delesto Delfzijl, in kiloton CO_2 per year for 2016 and 2023 as reported by the Dutch Emissions Authority (NEa 2021, 2024).



3 Options for decarbonisation

A definitive path for Nobian's decarbonisation transition was set upon the signing of the tailor-made agreement. The strategy consists of three types of interventions: (1) installation of mechanical vapour recompression (MVR) units and phase out of multi-effect evaporators (MEE), and the closure of the CHP Delesto 1 and the CHP in Hengelo, (2) installation of energy-efficient chlor-alkali electrolysers, and (3) brine recovery from wastewater (Rijksoverheid 2024).

Five potential decarbonisation projects are discussed in Nobian's Expression of Principles (Rijksoverheid 2022) and the Joint Letter of Intent (Rijksoverheid 2023). The installation of MVR units in Hengelo and Delfzijl was previously referred to as 'projects 1 and 2' and the electrolyser replacement as 'project 3'. The brine recovery installation was one of two 'portfolio projects' discussed in the JLoI. Project 4 (energy storage in salt caverns) and the rest of the portfolio of projects discussed in the JLoI are not part of the tailor-made agreement and are, therefore, not discussed in this report.

The original reports by Scherpier & Eerens (2021a, 2021b) and the MIDDEN database (PBL 2024) include potential decarbonisation options other than those discussed in this chapter. These options are no longer considered for Nobian in this report nor in future versions of the MIDDEN database[1]. Decarbonisation options for the other salt or chlor-alkali producers in the Netherlands – including Frisia Zout Harlingen, Nedmag Veendam, and SABIC Bergen op Zoom – have not been updated.

3.1 Mechanical Vapour Recompression

Through the construction of four Mechanical Vapour Recompression units, Nobian aims to largely electrify its steam generation and, in turn, its salt production. At Nobian's facilities in Delfzijl and Hengelo, two new MVRs will be constructed with a total capacity of 26 MW per location (Westerveld 2024). Brine vaporisation accounts for 95% of the total energy demand of the salt production process (Scherpbier & Eerens 2021a). Nobian's facilities in Delfzijl and Hengelo will both still have one MEE in 2030 for which the steam will be bought from nearby companies, such as the Twence residential waste plant in Hengelo and the Eneco and EEW plants in Delfzijl (Rijksoverheid 2024).

Figure 3.1 illustrates the salt production process at Nobian's facilities after the installation of the MVRs in 2030. In an MVR, the water vapour that is evaporated from the brine is pressurised to steam, which is circulated back into the system to be used to evaporate more brine. Since steam can be kept within the system of an MVR, its steam requirement can be 95% lower than that of an MEE. Due to the lower steam demands, Nobian wants to phase out the Delesto 1 CHP plant in Delfzijl and its CHP plant in Hengelo. The Delesto 2, which operates as a peak-load electricity plant in Delfzijl, will remain operational. Figure 3.2 shows an estimation of the mass and energy flows of brine vaporisation in the proposed configuration using MVRs.

[1] Referring to any future versions of the database that follow on MIDDEN version 0.4a (published January 2025).

The installation of MVRs in Delfzijl will also create 14 MW e-flex capacity. The new configuration will be operated in a flexible way, meaning that the installations can be ramped up and down when there is a shortage on the electricity grid (Rijksoverheid 2024).

Figure 3.1
Schematic of salt production process at Nobian's facilities after installation of the additional MVRs, adapted from Rijksoverheid (2024).

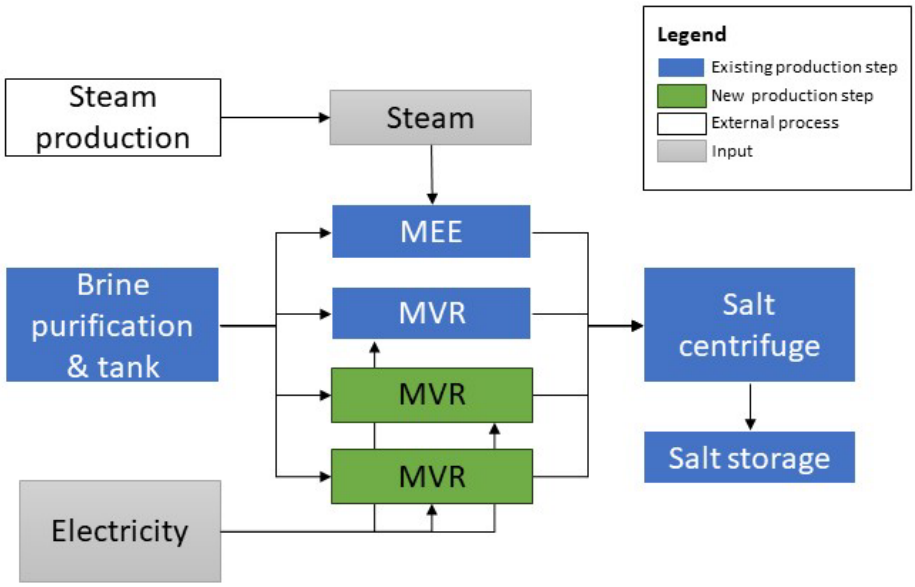
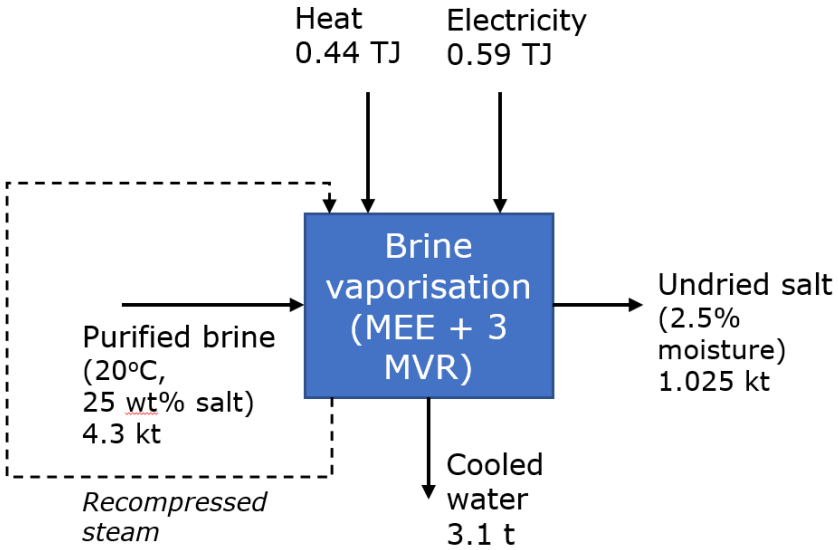


Figure 3.2
Estimation of mass and energy flows of brine vaporisation in the proposed configuration, adapted from PBL (2024).



Nobian estimates that the MVR-project will require a total investment of approximately €499 million, of which a maximum of €147.5 million will come from a government subsidy. The installation of the MVRs is the most costly intervention of the projects of the tailor-made agreement. The aim is to have the first MVR operational in Delfzijl in the first half of 2028. In the year(s) following that, electrification will proceed at the Hengelo plant, which is aimed to be fully electrified at the end of 2029 (Rijksoverheid 2024).

The SDE++ scheme determines the investment costs of an MVR unit at €1346 per kW_{th} (Lensink & Eggink 2025). Based on the expected MVR capacity, the investment costs for Nobian's MVR units would be approximately €120 million per location and a total investment of €240 million for the construction of the MVRs in both Delfzijl and Hengelo. The tailor-made agreement estimated an investment of €500 million in the tailor-made agreement, which is higher than the estimate based on the SDE++. However, the incorporation of the MVR units in Nobian salt factories will require large-scale overhauls of the production processes, which would add extra costs for demolition and construction and for process engineering. The tailor-made agreement does not specify this.

3.2 Energy-efficient chlor-alkali electrolysis

With the installation of 24 new zero-gap electrolysers in its Rotterdam chlor-alkali factory, Nobian aims to improve the energy-efficiency of the site. Zero-gap electrolysers were considered a viable decarbonisation option in the original MIDDEN-report by Scherpbier & Eerens (2021b) and are, therefore, already included in the MIDDEN data. As part of this update report, the electricity demand for chlor-alkali electrolysis alternatives in the MIDDEN data were reviewed and updated. Euro Chlor (2024) estimates that the electricity demand of the European chlor-alkali industry is approximately 9.5 terajoule per kiloton chlorine. Electrolysis is the most electricity-intensive step of the chlorine production process, accounting for almost 90% of the electricity demand (Scherpbier & Eerens 2021b). This would mean that, based on these updated statistics, electrolysis requires 8.6 terajoule electricity per kiloton chlorine that is produced. According to the tailor-made agreement, Nobian expects a 15% reduction in electricity demand in 2030 following the installation of the zero-gap electrolysers. Following this, the electricity demand of the zero-gap electrolysers would be about 7.3 terajoule electricity per kiloton chlorine. Table 3.1 shows the revised electricity demands for chlor-alkali electrolysis by Nobian.

Alkaline electrolysers require large up-front investments due to the high costs of the stack itself (Shanian & Savadogo 2024) and the necessary infrastructure to deal with the corrosive caustic soda that is produced during electrolysis (Rijksoverheid 2024). The replacement of the electrolysers will take place in two phases, with the first twelve to be replaced in early 2027. This replacement will require an investment of approximately €116 million, of which about €25 million is covered by a government subsidy as agreed upon in the tailor-made agreement. Nobian aims to complete the upgrade of its Rotterdam facility in the first half of 2029, the total investment of which will amount to approximately €230 million.

Nobian Rotterdam currently has 180 MW of electrolyser capacity, which already provides 25 MW of E-flex capacity (Westerveld 2024). After the replacement of all the electrolysers in Rotterdam in 2029, an additional 25 MW E-flex capacity will be created (Rijksoverheid 2024) and 18 MW of capacity will be available on the electricity grid. In practice, this flexibility entails that Nobian can turn down part of its electrolyser capacity when needed to relieve congestion on the electricity grid.

Table 3.1
Electricity demand in per kt chlorine gas (80% chlorine) produced from forced circulation brine electrolysis compared with zero-gap brine electrolysis.

	Revised electricity input [TJ/kt]
Forced circulation electrolysis	8.6
Zero gap electrolysis	7.3

3.3 Brine recovery from wastewater

A third pillar in Nobian's decarbonisation strategy is 'project Delsalto', which is aimed at increasing the circularity at Nobian's electrolysis plant in Delfzijl. The Delfzijl electrolyser is the smaller one of Nobian's two plants with an annual production capacity of around 100 kilotonne chlorine (Scherpbier & Eerens 2021b). In its current configuration, the plant discharges wastewater containing substantial amounts of sodium salt into a nearby canal. The sodium salts in the wastewater are byproducts of a reaction between caustic soda and chloride at the electrolysis facility (Rijksoverheid 2024).

By constructing a Brine Recovery Unit ('Pekel Terugwin Unit') in Delfzijl, Nobian aims to reuse the majority of the discharged salt from the wastewater. As an added benefit, the purification necessary to make the discharged brine suitable for electrolysis also filters out several other substances in the wastewater that are discharged by the nearby chemical plant Delamine (Table 3.2). The annual discharge reduction in Table 3.2 is, therefore, dependent on the production by Delamine. The estimates in the table are based on the discharge if Delamine is operating at full capacity. Approximately 63 tonnes of this discharge consists of the ethylenediamine, which is classified as a 'substance of very high concern' (Rijksoverheid 2024). The recovered brine reduces the demand of 'virgin' salt won from mining in the province of Groningen, where the Delfzijl plant is located. Nobian expects to save 350,000 m^3 water as result of less salt extraction (Rijksoverheid 2024).

Table 3.2
Expected annual discharge reduction onto the Zeehavenkanaal in the tailor-made agreement (Rijksoverheid 2024).

	Discharge reduction
Ethylenediamine [t]	57
Ammonia [t]	8
Sodium salt [kt]	104

Several new installations and infrastructure need to be constructed in Delfzijl to facilitate the brine recovery and the purification of the wastewater, including the aforementioned Brine Recovery Unit, a brine mixing tank, a gas scrubber, and a (bi)sulfite storage unit (Rijksoverheid 2024). The details of the wastewater brine recovery process are not specified in the tailor-made agreement. The project requires a total investment of €27 million, of which 45% will be covered by government

subsidies made available through the tailor-made agreement. Nobian aims to start the construction halfway through 2026 and have the plant running, at the earliest, in the first half of 2028 (Rijksoverheid 2024).

3.4 Estimated CO_2-emission reduction by 2030

Natural gas is currently used to produce the necessary steam for salt production. Following the MIDDEN database (PBL 2024), an estimated 7.5 petajoule natural gas was used to produce the steam for Nobian's salt production in 2023 (Table 3.3). Electrification at Nobian's salt plants will significantly decrease the need for steam, which will lead to the intended closure of Nobian's two natural-gas powered CHP plants in Delfzijl and Hengelo in 2030. The operation of these plants resulted in approximately 550 kiloton CO_2 emissions in 2020. With the closure of these plants in 2030, these emissions will therefore largely disappear. The tailor-made agreement estimates the total reduction in 2030 at 524 kiloton CO_2 compared to Nobian's emissions in 2020.

The interventions discussed above will increase the electricity demand of both of Nobian's salt plants and decrease that of the electrolysis plant in Rotterdam. Based on the technological parameters described Figure 3.2, Table 3.1, and the MIDDEN database (PBL 2024), we made an estimate of the electricity demand of Nobian's three Dutch locations (Table 3.3). It was assumed that the production of all three sites does not change significantly in the coming years. For chlorine production, Nobian only uses a small number of zero-gap electrolysers in the current configuration. We therefore assumed that 15% of the produced chlorine in 2023 is made using zero-gap electrolysis. Following Scherpbier & Eerens (2021a, 2021b), brine vaporisation accounts for 95% of the total electricity demand of salt production, and chlor-alkali electrolysis for 90% of the total electricity demand of chlorine production.

Table 3.3
Estimated natural gas and electricity demand of salt and chlorine production by Nobian in 2023 and 2030.

Production process	Energy carier	2023	2030
Salt production	Natural gas demand [PJ/yr]	7.5	0
	Electricity demand [PJ/yr]	0.8	2.3
Chlorine production	Electricity demand [PJ/yr]	4.2	3.7

By 2030, Nobian aims to have 66% of the electricity used for the operation of their plants in The Netherlands, Germany, and Denmark coming from renewable sources. The renewable electricity supply will be achieved via Power-Purchase-Agreements (PPAs) and Guarantees-of-Origins (GOOs). Nobian has already entered into several PPAs with suppliers of renewable electricity for their operation in the Netherlands (Nobian Industrial Chemicals B.V. 2025), resulting in a largely renewable electricity supply for their Dutch factories. While Nobian's Dutch electricity supply will be considered fully renewable in 2030, the Dutch electricity grid – from which Nobian obtains its electricity – is not. In 2030, the national electricity mix is expected to consist of 72% renewable electricity (PBL, TNO, CBS, and RIVM 2024). In 2040, Nobian aims to have a completely renewable electricity supply for all their production sites, both inside and outside the Netherlands (Rijksoverheid 2024; Nobian Industrial Chemicals B.V. 2025).

Nobian Rotterdam also has its own on-site CHP plant, which emitted around 100 kiloton CO_2 emissions in 2023 (Nea, 2024). The steam and electricity produced by this plant is used for chlorine production at Nobian's own plant (Scherpbier & Eerens, 2021b), but the CHP also produces steam for third parties in the Botlek cluster (Lalkens 2025). Nobian's Rotterdam CHP is not mentioned in the tailor-made agreement.

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