ENVIRONMENTAL IMPACT REPORT SUMMARY

Doel Nuclear Power Station for LTO of Doel 1 and 2

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Abbreviations

AOX	Adsorbable organic halogen compounds
BAT	Best Available Technologies
BOC	Biological Oxygen Consumption
CO	Carbon Oxide
CO_2	Carbon Dioxide
COC	Chemical Oxygen Consumption
dB	Decibel
POP	Post Operational Phase
FANC	Federal Agency for Nuclear Control
GEN	Large Nature Areas
GGG	Controlled reduced tidal range
GNH	Nuclear Auxiliary Services Building
BES	Building Emergency Systems
RSIP	Regional Spatial Implementation Plan
IAEA	International Atomic Energy Agency
CT	Conservation Target
INBO	Institute for Nature and Forest Research
DNPS	Doel Nuclear Power Station
KCD-1/2/3/4	Doel Nuclear Power Station (unit 1/2/3/4)
LTO	Long Term Operation
EIR	Environmental Impact Report
EQS	Environmental Quality Standard
MWe	MegaWatt electric

NIRAS	National Institution for Radioactive Waste and Enriched Fissile Materials
NO_x	Nitrogen oxides
OVAM	Public Flemish Waste Company
PAH	Polycyclic Aromatic Hydrocarbons
PM	Fine Dust
PSA	Probabilistic safety assessment
PWR	Pressurized Water Reactor
SPA	Special Protection Area
FCB	Nuclear Fuel Container Building
SCK•CEN	Nuclear Energy Study Centre - Centre d'Etude de l'Energie Nucléaire
SF^2	Spent Fuel Storage Facility
SO_2	Sulphur dioxide
SO_x	Sulfur Oxides
FEN	Flemish Ecological Network
Vlarebo	Flemish regulations on soil remediation
FEA	Flemish Environmental Agency.
WAB	Water and Waste Treatment

Systems list of Doel Nuclear Power Station

FCV	Filtered Containment Vent
FW	Feed water circuit
GNH	Building of Nuclear Auxiliary Services
BES	Emergency Systems Building
RGB	Reactor Building

1 Introduction

This is the Non-Technical Summary (NTS) of the Environmental Impact Report (EIR) "*Doel Nuclear Power Station for LTO of Doel 1 and 2*". This document is a brief summary of the Environmental Impact Report and is intended for the public and other interested parties. For the detailed technical information, please see the actual environmental impact report.

An EIR is a public document that examines and assesses the environmental impacts of a planning process or project and any alternatives to that planning process or project. The EIR does not decide whether the project or planned process will be licensed, this is decided by the licensing authority taking the EIR into account.

1.1 Reader's Guide

Chapter 1 describes the background for the EIR. It also defines both the subject (the Project) of the EIR and the alternative to the Project (the Zero Alternative). It also describes the baseline situation, in order to make a comparison between the Project and the Zero Alternative in terms of environmental impacts.

Chapter 2 provides a general overview of the Doel nuclear power station (KCD) and the concept of nuclear fission. As Chapter 1 requires a certain level of knowledge about nuclear technology, uninitiated readers are advised to read Chapter 2 first.

Chapters 3 and 4 mention the environmental aspects that have been studied and, for each aspect, describe the environmental impacts associated with implementation of the Project and of the Zero Alternative. Both are then compared to the baseline situation. It also describes possible measures to mitigate environmental impacts and identifies any gaps in knowledge.

Finally, Chapter 5 provides a summary conclusion regarding the impacts described in Chapters 3 and 4.

A division is made between non-radiological aspects (Chapter 3) and radiological aspects (Chapter 4). The non-radiological part was prepared by Arcadis and the radiological part was prepared by NRG.

1.2 Rationale for the EIR

Doel Nuclear Power Station (KCD) consists of four nuclear units, KCD-1, KCD-2, KCD-3 and KCD-4. Until 2003, all nuclear units at Doel were licensed for an indefinite period. However, in 2003, the operating time of the units was limited by law and the dates when electricity production must be stopped were set. In 2003, it was determined that KCD-1 and KCD-2 should stop in 2015 while KCD-3 and KCD-4 should stop in 2022 and 2025, respectively.

In 2015, a change in the law was implemented with the aim of ensuring security of supply. This law has enabled KCD-1 to produce electricity until February 15, 2025. For KCD-2, the decommissioning date has been pushed back to December 1, 2025.

The 2015 law has been appealed before the Constitutional Court, which had posed several questions to the European Court of Justice. The European Court of Justice, in its ruling C-441/17 of July 29, 2019, stated that the 2015 Act constitutes the first stage of a project's permitting process (referred to in the EIR as the Project). Such a Project, according to the ECJ's assessment, poses a risk of environmental impacts similar to those that occurred during the original commissioning of KCD's nuclear units. It was decided to prepare an EIR for:

- the law to be adopted by the legislature for extended electricity production and
- the associated work, which should be considered together as one and the same "project".

For practical reasons, it was decided to prepare two separate EIRs, but they will need to be evaluated in conjunction. The first is an environmental impact assessment at the strategic level, which is prepared by SCK•CEN (Studiecentrum voor Kernenergie • *Centre d'Etude de l'Energie Nucléair*e). The second environmental impact assessment deals with the concrete work to be carried out as a result of the law to be adopted by the legislature on extended electricity production, also and considering the cross-border environmental impacts.

Because the period to be studied (2015-2025) had already partially passed by the time the EIR was prepared, available measurement data could be used in some cases. Therefore, the data used in this EIR covers both existing data up to the date of the report's preparation, as well as projections.

1.3 Project

The owner and operator of KCD-1 and KCD-2 (Electrabel) wants to operate these units beyond 2015. For this reason, Electrabel launched the Project that focuses on Long Term Operation (LTO). The Project ensures that aging processes and their potential consequences are controlled. It is assured that the systems, structures and components will continue to function as intended during the extended operating period. It also raises the safety level of the plants to the highest possible level.

As part of the Project, we examined Electrabel's technical and organizational ability to safely operate KCD-1 and KCD-2 for a ten-year period beyond 2015. To make this possible, Electrabel has formulated a number of improvements in consultation with the competent authority*(Federal Agency for Nuclear Control*, FANC). The main improvements are:

- The fire suppression systems will be modified to be earthquake resistant. As a result, KCD-1 and KCD-2 will be better protected against fire caused by an earthquake.
- Basements in which safety systems are installed are protected from flooding.
- Emergency systems will be made more reliable and automatic.

- A Filtered Containment Vent (FCV) system will be installed in the reactor buildings. This system protects the "containment" from excessive overpressure, avoiding unacceptable radiological emissions to the environment.

The implementation of the technical improvements constitutes the first phase of the Project (operational phase of the Project between 2015-2018). In this phase, KCD-1 and KCD-2 are operated normally. Technical improvements are carried out mainly during overhauls (the annual periods when the reactor is shut down and fuel elements are changed and replaced). This phase is followed by the operational phase (operational phase in future situation) in which KCD-1 and KCD-2 are operated with the technical improvements completed. This operational phase will run from 2019 through 2025.

At the end of the licensed operating period, Electrabel will stop operating KCD-1 and KCD-2. This begins with the final shutdown of the reactor, followed by the start of cleaning the systems. The cleaning of the systems is part of the *Post Operational Phase* (POP), which prepares for the decommissioning of the unit. During the POP, as many active or activated components are removed so that employees receive the lowest possible dose during decommissioning. This phase ends when the last irradiated fuel elements have been transported to the *Fuel Container Building* (SCG) and as many radioactive materials and contaminants as possible have been removed. This is followed by the dismantling of the plant.

As decommissioning is outside the period to be studied in this EIR (2015 - 2025), it is not part of the Project. Decommissioning is subject to its own specific licensing process, which includes an environmental impact assessment.

Currently, KCD-3 and KCD-4 are scheduled to cease operation in 2022 and 2025, respectively. In order to unambiguously determine the impacts of the Project, this EIR has assumed that the environmental impacts due to KCD-3 and KCD-4 will remain the same after the cessation of electricity generation as they were before the cessation. This is conservative assumption: it takes into account a longer period of environmental impact due to operation than will actually be the case. Figure 1-1 is a schematic overview of the phases.

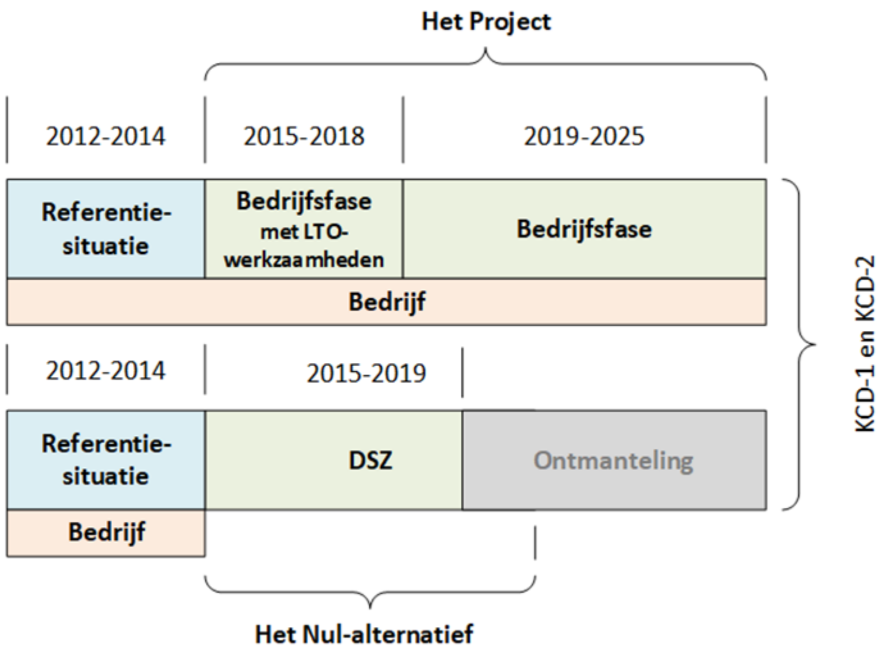


Figure 1-1 Phases within the Project

Therefore, the EIR considers the environmental impacts resulting from operating the entire KCD site until 2025. This means that in addition to nuclear units KCD-1 and KCD-2, KCD-3 and KCD-4 are also considered, as well as the other buildings (see Chapter 2) at the KCD site.

1.4 Zero alternative

An important part of an EIR is the examination of possible alternatives to the proposed initiative. For example, if a new plant is the reason for drafting the EIR, the extent to which there are alternatives, both technological and otherwise, will be examined. In the case of KCD-1 and KCD-2, the number of alternatives is limited; there are no plans for expansion or modification of the site. The EIR therefore formulated and examined one alternative for implementation of the Project. The alternative is the so-called "Zero Alternative".

The Zero alternative means that the Project is not implemented and it considers the situation where the KCD-1 and KCD-2 units have stopped producing electricity in 2015, reducing the available electricity production capacity. There are numerous options for the alternative supply of electricity to compensate for this loss of production and they depend on political and market decisions, particularly based on technical and economic considerations. These are not studied in this EIR and are considered in the Strategic EIR.

Thus, in the Zero Alternative, the POP phase starts in 2015, after KCD-1 and KCD-2 are stopped. However, there will be no difference in the duration of the POP phase after the LTO (Project) and after immediate shutdown (Zero Alternative); the POP phase will start only 10 years later.

1.5 Baseline situation

In order to make an objective comparison between implementation of the Project or the alternative, a baseline situation was defined in the EIR. The baseline situation is defined as the period 2012-2014.

In 2015, the implementation of the work associated with the Project began. As a result, 2014 is the last year without impact from the Project. However, within normal operation, fluctuations in production occur. As a result, there are also fluctuations in the discharges and impact of the nuclear power plant on the environment. To get a better idea of the average situation, not only 2014 was considered, but also at least the two preceding years, namely 2012 and 2013. The average values over this period are then used as the reference period for the purposes of the baseline situation.

1.6 Parallel projects

Significant changes will occur during the period under study (2015-2025). One of the important changes taking place in parallel with the Project is the implementation of the SF^2 project. The SF^2 project aims to increase the storage capacity for spent fuel at the KCD site. The SF^2 project envisions that the additional storage capacity that becomes available will be used for the spent fuel from KCD-3 and KCD-4. So, the SF^2 project is not necessary for the operation of KCD-1 and KCD-2 until 2025.

The SF^2 project was not yet scheduled to begin in 2015. The changes involved are not part of the Project. The environmental assessment of the SF^2 project is described in a separate environmental impact assessment.

2 Description of KCD

2.1 Location

The four units of KCD, operated by Electrabel SA, have a total capacity of 3,720 MWe. All of these nuclear units are located at the Doel site. The KCD site is located in the far north of what is described as the Waaslandhaven (Antwerp port area on the left bank). Doel is part of the municipality of Beveren in the province of East Flanders. The location is indicated in Figure 1-2 below.

Figure 1-2 Location (in red) of KCD

The nuclear units, consisting of the reactor buildings and support buildings, are located at the site. In addition, at the KCD site there are the *Water and Waste Treatment Building* (WAB Building) and the FCB which contain radioactive material, and a number of other buildings where basically no radioactive material is stored, see Figure 1-3.

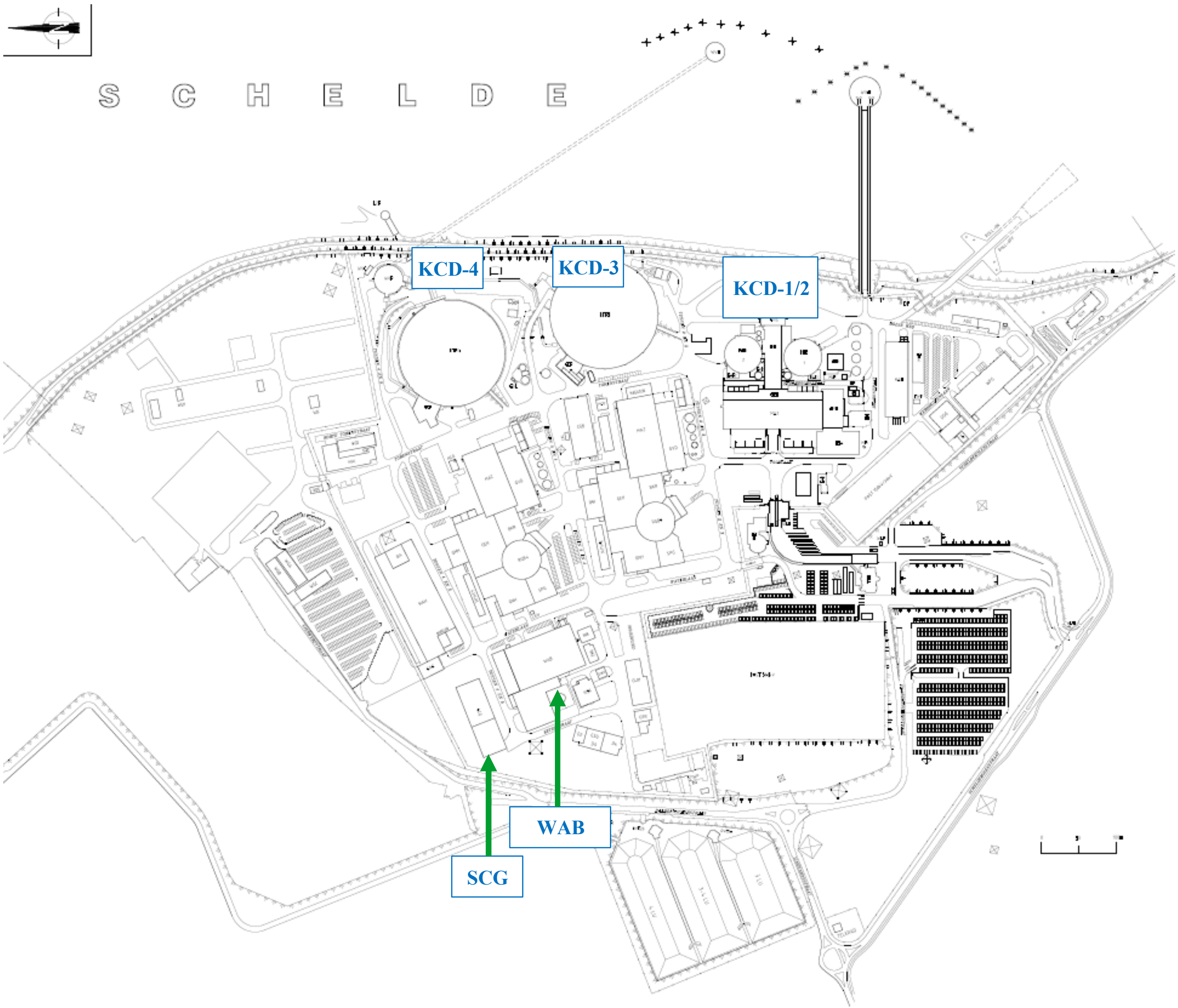
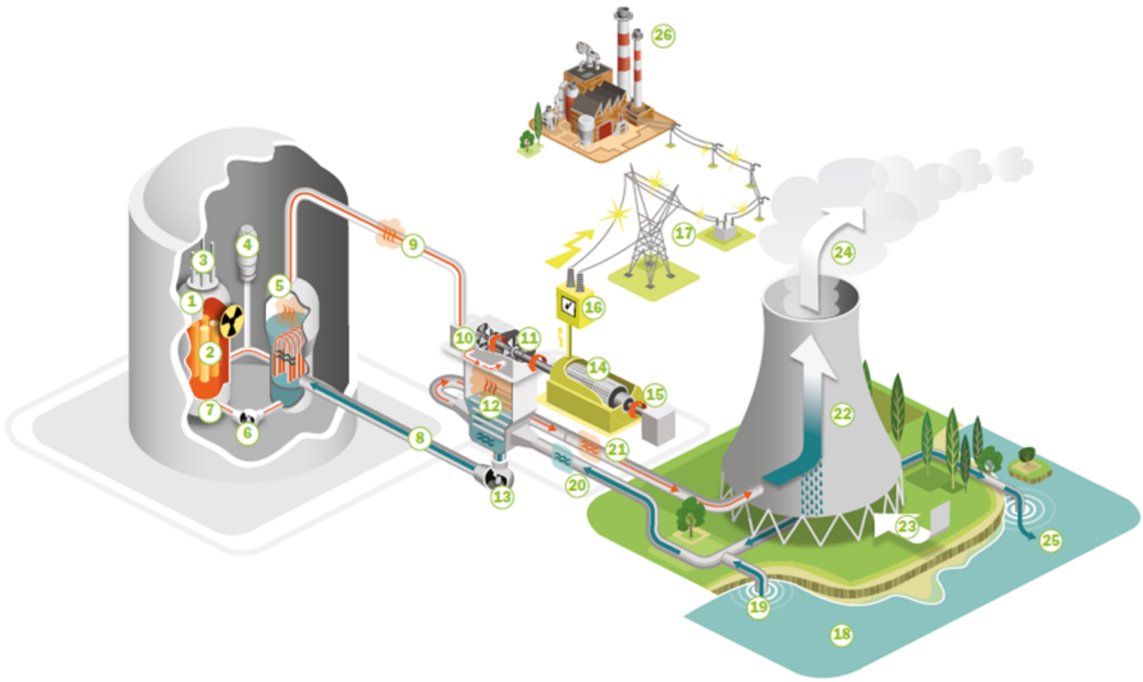


Figure 1-3 Layout plan of the Doel site

2.2 Operation of nuclear units

The four units at Doel are of the Pressurized Water Reactors (PWR) type. In this type of reactor, heat is generated in the reactor vessel as a result of nuclear fission. The heat is dissipated by cooling water, which is passed through the reactor vessel at high pressure. The operation of such a type of reactor is shown in the figure below:



1. Reactor
2. Splijtstofstiften
3. Regelstaven
4. Drukregelvat
5. Stoomgenerator
6. Primaire pomp
7. Voedingswater primaire kring
8. Voedingswater secundaire kring
9. Stoom secundaire kring
10. Hogedrukturbine
11. Lagedrukturbine
12. Condensor
13. Voedingspomp
14. Alternator
15. Bekrachtiger alternator
16. Transformator
17. Hoogspanningslijn
18. Waterloop (Schelde)
19. Opname koelwater
20. Koud koelwater
21. Opgewarmd koelwater
22. Koeltoren
23. Opwaartse luchtstroom
24. Waterdamp
25. Lozing koelwater
26. Consumenten

Figure 1-4: Operation of a Pressurized Water Reactor (PWR)

The heat is removed using three circuits. The first circuit, also called the primary circuit (number 7), is the circuit from which nuclear reactors derive their name. This circuit contains water under high pressure. The high pressure prevents the water from starting to boil as a result of the heat produced during the nuclear reaction. The water heated under high pressure then flows from the reactor to a steam generator (number 5; essentially a heat exchanger) where the water is pumped through thousands of tubes. On the other side of these tubes, the water from the secondary circuit evaporates into steam. Then the water from the primary circuit is fed back to the reactor through the primary pumps. The primary circuit is completely separated from the secondary one, thus avoiding that any radioactive materials present would enter the secondary circuit.

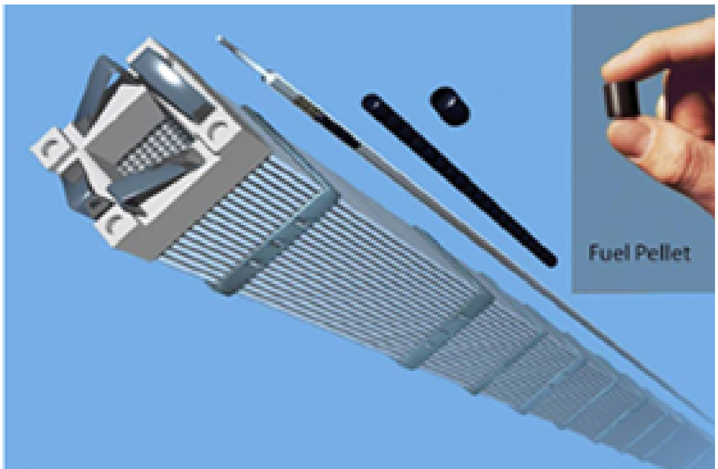
Steam from the secondary circuit (number 8) turns a turbine (numbers 10 and 11) and its associated alternator (number 14). The alternator generates electricity.

The steam then leaves the turbine and travels to the condenser to be cooled by water from the third (tertiary) circuit (numbers 20 and 21). This circuit is fed by Scheldt water. The steam from the secondary circuit releases its heat to the Scheldt water from the tertiary circuit. The steam cools down, condenses into water and goes back to the steam generators.

The cooling of the water from the secondary circuit causes this Scheldt water to warm up slightly. Therefore, it is first cooled in the cooling tower (number 22) before it either goes back to the condenser or flows back into the Scheldt.

2.3 Fissile material

The fission reaction in the core, which produces heat, is made possible by the fissile material present. The nuclear fuel takes the form of uranium oxide pellets. The pellets are stacked in closed tubes about 4 m high: the combination of the pellets and the tube is usually called the fuel rod. Fuel rods are assembled in several bundles to form a metal structure called a "fuel element" (see Figure 1-5). It is in this form that the nuclear fuel is delivered to the site and used.



Fuel element (bottom) and fuel pellet (top right)

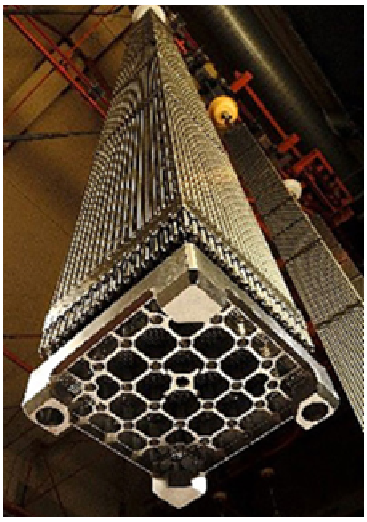


Figure 1-5 Nuclear fuel element

The part where the fission reaction takes place is called the core. The fission reaction takes place in a steel reactor vessel filled with water. The fuel elements are placed the reactor vessel in a well-defined order and remain in the vessel for approximately 48 months. It follows that each year, about a quarter of the fuel elements are removed from the reactor during an overhaul and replaced with new fuel elements. Spent fuel elements from KCD-1 and KCD-2 are stored in common fuel pools in the Nuclear Auxiliary Services Building (GNH). When the spent fuel elements are sufficiently cooled, they are transferred to the FCB.

3 Effects of the non-radiological aspects

This chapter describes the non-radiological environmental impacts as a result of the project. The following disciplines are addressed in the EIR:

- Normal operation
    - soil;
    - water;
    - noise & vibration;
    - air & climate;
    - biodiversity; landscape,
    - architectural heritage & archaeology;
    - human - mobility;
    - human - health and
    - waste.
- Accident situations

For the Project, impacts are first assessed from the 2015-2018 operational phase, together with the works related to LTO, compared to the situation without the operation of KCD. The operational phase in the future situation (period 2019-2025) represents the effects of LTO from KCD-1 and KCD-2 relative to the baseline situation. The impact assessment of the zero alternative is not significantly different from that of the project. However, in the zero alternative, effects will decrease as early as 2015 rather than as late as 2025.

The baseline situation is described for each discipline.

3.1 Soil

3.1.1 Baseline situation

The site of the power station is surrounded by open space. On the left bank of the Scheldt, this open space is mainly used for agricultural activities. The wider environment of the nuclear power plant is characterised by strong industrialisation (port area). The Antwerp port area is characterised by the presence of a (petro)chemical cluster on the one hand and container terminals on the other.

Locally, the topography of the area has been disrupted, as a result of the construction of the industrial zones, but the industrial sites between the Scheldt and the canal docks themselves are fairly flat. The KCD site was raised by about 6 metres compared to the surrounding polders using sand from the Scheldt.

According to the soil map of Belgium, moderately wet to wet, light sandy loam to (heavy) clay soils with no profile development initially occurred in the study area. The elevation created an anthropogenic soil without profile structure, consisting mainly of tertiary sand, but also clay sediments. Among the artificial elevations are the alluvial deposits from the Scheldt. They are largely composed of sand loam and clay, in which locally sandy, loamy and peaty intermediate layers occur.

By raising the terrain with predominantly permeable sandy material, another aquifer was created above the original aquifer, separated from each other by the clayey polder deposits.

The study area is not situated in protected water catchment areas.

Within the framework of the Soil Decree, periodic soil analysis is carried out on the site in view of the Vlarebo activities present. Soil analyses were also carried out in the past related to the transfer of plots of land. The last soil analysis submitted to OVAM dates from October 2019.

KCD stores numerous substances that can be a possible source of soil and/or groundwater contamination. For all current potential sources of contamination on the KCD sites, the necessary soil protection measures are always taken to prevent contamination of soil and groundwater. For all future new potential sources of pollution, the necessary soil protection measures will also be taken at all times.

In the event of an emergency involving soil contamination, the soil contamination is removed as soon as possible. A descriptive soil analysis is then carried out to confirm the removal. If the contamination has not been sufficiently removed, soil decontamination will be carried out.

3.1.2 Impact assessment

The work that has taken place in the context of the adjustments for LTO and the operational phase of KCD in the future situation (including POP) has a negligible impact on the soil.After all, in the past, the terrain was raised with sand from the Scheldt, so that the top 5 to 6 m mainly has a sandy texture and no profile development. The impact on the soil structure and profile development is therefore assessed negligible.

However, incidents that have an impact on soil hygiene cannot be ruled out. However, KCD-1 and KCD-2 are currently equipped with both technical and organisational measures to prevent or counteract possible contamination as much as possible. The continued operation of the nuclear power plant (including the POP) will always be carried out in accordance with the latest available good practices, thus significantly reducing the risk of soil contamination. No additional mitigating measures or recommendations are considered necessary.

The operation of the Doel 1 and 2 units has no impact on the salt deposition in the environment, and thus on soil use and soil suitability.

As far as soil is concerned, there is no difference between the POP in 2015 (= zero alternative) or in 2025. The repositories and the risk activities on the site would be discontinued as from 2015. However, the risk of soil and groundwater contamination is considered to be controlled.

There are no cross-border or cumulative effects for the soil section.

3.2 Water

3.2.1 Baseline situation

3.2.1.1 Hydrography

The KCD site is located on the left bank of the river Scheldt.

The Scheldt at Doel is a tidal river, so there are two types of flows. First of all the tidal flows (low tide and high tide) and secondly the discharge of excess flow from the hydrographic hinterland to the sea. The tidal flows are very large and vary with the cycle of the tide. The tidal flow increases downstream.

To give you some idea of size: for an average tide passing at Liefkenshoek, high tide and low tide have an average flow of 5,300 and 5,400 m^3/s respectively. The durations are different: high tide lasts just over five and a half hours, while low tide lasts for almost seven hours. During high tide or low tide there is - on average - an instantaneous maximum flow of 9,400 or 8,300 m^3/s, respectively. In total, this is a high tide volume of 115 Mm^3 and a low tide volume equal to 123 Mm^3 (Source: Plancke et al., 2017).

The difference in tidal volume over time between the high tide and low time, immediately shows that there is an average excess flow rate of about 180 m^3/s across the entire tidal period of 12 hours and 25 minutes on average.

The bathymetry of the Scheldt near KCD can be described in a simplified way using the average rectangular bathymetry. The average depth of the Scheldt at low tide here is 7.8 m and its width is about 1,100 m. At the upstream end of the tidal channel of the Doel plate, there is a breakwater. A breakwater partially curbs the high tide flow and leads it to the overflow of the existing low tide gully. Here, the low tide flow is concentrated more in the main waterway and as a result, due to the increase in the sand transport capacity, greater erosion in the fairway is achieved and consequently greater natural depths are maintained. A breakwater in a sense defines a plate area and prevents the formation of continuous secondary low tide gullies in the plate system, which in their natural state show certain evolutions that can have a detrimental effect on the conservation of the waterways. It should be noted that in view of the specific location of the discharge point at the head of the Doel plate, it has been assumed for the situation at low tide that the largest volume of water flows back through this plate. At low tide, a depth of 3 m and a width of 300 m are taken into account for the Doel plate.

South of KCD there is the Doorloop, a watercourse of 3rd category managed by the Polder of the Land van Waas. It flows into the Scheldt, just upstream from KCD. KCD has no discharge points on this watercourse.

3.2.1.2 Surface water quality

Upstream and downstream of KCD, the Scheldt has to comply with the guide values determining good ecological and chemical status for the type "Transitional water - brackish macrotidal lowland estuary" (O1b), which can be found in Annex 2.3.1 of VLAREM II. Due to the brackish nature of the water in the Scheldt estuary, the objectives for chlorides, sulphate and conductivity are not applicable.

On the basis of the data from FEA's monitoring network, it can be concluded that the Scheldt, both upstream and downstream of the KCD discharge point, does not meet all quality objectives. The most critical parameters are temperature (a few days above 25°C in summer), dissolved oxygen (the P10 value of 6 mg O2/L is not always respected), chemical oxygen consumption (COC), nitrate+nitrite+ammonium, dissolved boron, arsenic, beryllium, cadmium and uranium. However, based on the Prati index for dissolved oxygen, a gradual improvement of the oxygen balance at all measuring points is observed over time. There is also an improvement in the oxygen levels, downstream of KCD. This can be explained by the greater tidal flow in the downstream direction.

Also the Doorloop next to KCD does not meet all quality objectives. The most critical parameters are total phosphorus and dissolved uranium.

3.2.1.3 Water testing maps: susceptibility to flooding, infiltration, groundwater flow and erosion and location within a winter bed

KCD's site is located in a zone designated as follows, according to the water testing maps:

- not susceptible to flooding. The lower-lying polders to the west of KCD have been identified as potentially sensitive to flooding.
- non infiltration-sensitive
- very sensitive to groundwater flow (type 1)
- slopes of 0.5% or 0.5-5%
- not situated in a winter bed

3.2.1.4 Water supply/water balance

KCD uses the following water sources:

- <u>Mains water (city water)</u>: is used mainly for the production of demineralised water used for steam production in the secondary circuit, for the replenishment of cooling ponds and for sanitary purposes.
- <u>Scheldt water</u>: is almost exclusively used as cooling water in the tertiary circuit. The cooling water is extracted from the Scheldt and discharged back into the Scheldt after use. Part of the cooling water evaporates in 2 cooling towers (Doel 3 and Doel 4). A very small fraction of the surface water is used for the production of process water by distillation.

3.2.1.5 Internal sewerage system

KCD has an internal sewage system for the removal of the various (waste) water flows.

KCD does not have a separate sewage system for rainwater. The sanitary waste water is collected together with the rainwater from the roofs and most of the paved surfaces and discharged to five collection wells. These wells are equipped with submersible pumps that pump the water to the Scheldt during heavy rainfall. Under normal circumstances, this water is purified in 5 biorotors before it is discharged into the Scheldt (H1 – H5).

In total there are 5 discharge points. Each biorotor has its own discharge point. The industrial waste water is discharged together with the cooling water via one collective discharge point (discharge pavilion).

Rainwater is not reused. The rainwater from roofs and most of the paved surfaces is collected in a joint system together with the sanitary wastewater and purified by means of five biorotors. The water from the car parks at the entrance drains into the nearby Doorloop. Reuse of rainwater for the production of demineralised water, use as cooling water or for sanitary purposes is possible, in principle. However, the necessary infrastructure for the reuse of rainwater is lacking. The urban planning regulation on rainwater wells, infiltration facilities, buffer facilities and separate discharges of waste water and rainwater does not apply to existing buildings and structures.

The total surface area of the KCD site is 1,154,583 m². The KCD site is therefore 52% water permeable.

3.2.1.6 Wastewater streams

KCD discharges various wastewater streams:

- Sanitary waste water: the sanitary waste water is collected together with the rainwater from the roofs and discharged into the Scheldt after treatment in five biorotors;
- Industrial waste water: the industrial waste water is collected and discharged into the Scheldt, either separately or after treatment (see further);
- Cooling water: The cooling water from the tertiary circuit is extracted from the Scheldt and is largely discharged back into the Scheldt after use.

3.2.2 Impact assessment

3.2.2.1 Operational phase of the project between 2015-2018

3.2.2.1.1 LTO works

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1). As no drainage work was carried out during the works, no effects are expected for the Water section.

3.2.2.1.2 Water supply / water balance

The project includes a re-licensing of the existing KCD systems and the water balance for the base years 2013-2014 is considered representative for the production in the following years of the re-licensing period. Therefore, no relevant changes in water consumption and water balance are expected compared to the baseline situation.

3.2.2.1.3 Change in infiltration and discharge characteristics - Water test and climate change

The project includes the re-licensing of KCD's existing installations. Compared to the baseline situation, a limited number of paved surfaces have been added to the KCD site: Considering the limited amount of additional paved surfaces, there will be no harmful effects due to changes in surface water runoff, structural changes of watercourses, infiltration of rainwater, loss of quality of surface water or groundwater or changes in groundwater flow.

A frequent operation of KCD's sanitary wastewater collection wells into the Scheldt was found. The frequent operation of the sanitary wastewater collection wells is due to leaks of cooling water from the underground galleries and, to a lesser extent, groundwater in the mixed sewer system. These operations can cause peaks of nutrient concentrations in the Scheldt at the level of KCD. This is considered a negative effect (-2) compared to the situation without the operation of KCD. Rainwater is not reused. The urban planning regulation on rainwater wells, infiltration facilities, buffer facilities and separate discharges of waste water and rainwater does not apply to existing buildings and structures. The Water section recommends examining the feasibility of disconnecting rainwater from sanitary wastewater systems (source-based measure) for new projects and the possibility of installing additional collection capacity for sanitary wastewater (end-of-pipe measure) at concept level and according to the Best Available Technology.

Cumulative impact of climate change: Excess rainwater accumulates on the KCD site around certain buildings, both in the current climate and in the future climate in 2050, under FEA's high impact climate scenario (high summer). This is due to precipitation showers with a frequencyof 10, 100 and 1000 years. The flooding depth and the area to be flooded are limited both in the current climate and in the future climate in 2050. The increase in the floodable area in the future climate in 2050 compared to the current climate is also limited.

3.2.2.1.4 Surface water quality and thermal impact of cooling water discharge

The main impact of KCD on the water system compared to the situation without operation of KCD is the discharge of wastewater and cooling water into the Scheldt.

- Discharge of waste water:
  - The average concentration increase in the Scheldt due to the activities of KCD compared to the environmental quality standard (EQS) is less than 0.1% (negligible, 0). The parameters of nitrite and AOX were highlighted separately:
    - Average nitrite concentration in 2013 was above the then applicable discharge standard of 2 mg/L in industrial wastewater. In 2014, the average concentration was below the discharge standard but still peak concentrations were measured above the discharge standard. KCD carried out a study on the prevention and treatment of nitrite in industrial wastewater. In the decision dated 07/02/2019 (2018122825) the standard for nitrites was replaced by 8 mg N-NO2/L until 31 December 2021 and 2 mg N-NO2/L from 1 January 2022. By implementing some measures aimed at the source, the standard of 8 mg N-NO2/L can be respected in the period 2016-2018. The future norm of 2 mg N-NO2/L is sporadically exceeded but the concentration is on average below the norm.
    - Increased concentrations of AOX were measured in the sanitary and industrial waste water and in the cooling water, which is why this parameter is described separately. NaOCl is added to the cooling water as a conditioning agent to prevent growths in the cooling system. This can cause AOX. In 2014, a study was performed by KCD into the effect of NaOCl during possible oxidation of nitrite to nitrate. The formation of AOX was also investigated. The conversion of nitrite to nitrate is possible with a considerable excess of NaOCl. The dosage appears a striking influence on the AOX formation. An optimum conditioning regime can reduce the amount of NaOCl used and the period during which conditioning must be applied, ultimately leading to a reduction in emissions of organohalogens via cooling systems to surface water on an annual basis. By far the most important parameter appears to be the use of active chlorine. By regulating this consumption properly, it is possible to minimise the environmental impact (Berbee, 1997). Currently, the dosing of NaOCl at KCD is based on the analysis

of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on the control of biological growth on sample plates in the cooling towers and weight measurements of the gasket. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

- Discharge of cooling water:
  - Major temperature increases above 3°C due to KCD's cooling water discharge appear to occur only within the area of the breakwater, up to a maximum distance of approx. 1050 m from the discharge point (considerably negative effect, -3).
  - Relevant (acceptable) temperature increases between 1 and 3°C appear to occur during outgoing water and during low tide up to a maximum distance of approx. 1,300 m from the discharge point, the area that is still within the breakwater (negative effect, -2).
  - In the case of rising water, a relevant temperature rise occurs between 1 and 3 °C outside the breakwater up to a maximum of 500 m from the discharge point in an easterly direction and up to a maximum of 800 m upstream of the discharge point in a southerly direction (negative effect, -2).
  - For the specific situation of KCD, it can be stated that the area within the breakwater will form a heat barrier for certain aquatic organisms. For the area within the breakwater, the environmental quality standards with regard to temperature for the Scheldt due to the cooling water discharge of KCD are not met. However, the gully of the Scheldt east of the breakwater remains passable for aquatic organisms. The average cross-sectional surface area of the area within the breakwater does not exceed 25% of the cross-sectional area of the Scheldt. The gully of the Scheldt east of the breakwater is considered to be passable for aquatic organisms at all times.
  - Cumulative effects:
    - Other industrial cooling water discharges in the vicinity of KCD: This EIR incorporates the monitoring measure cf. the recommendation of INBO (Van den Bergh et al., 2013), namely that Engie provides routine monitoring of the spatial-temporal evolution of the temperature gradient between Hansweert and Antwerp. Given the fairly general availability of (thermal) satellite imagery and the experience with it abroad, this method may also be applied in the Zeeschelde to monitor the temperature gradient in the wider environment of KCD. In this way, changes in the cumulative thermal load on the Zeeschelde can be better visualized and detected.
    - Climate change will have a negative impact on the cooling capacity of the Scheldt water. The capacity of cooling water depends, among other things, on the temperature of the water taken in. With the current cooling capacity of KCD's cooling towers, the temperature difference between the entrance and exit of the cooling towers will likely remain the same. Due to the expected increase in the Scheldt temperature as a result of

climate change, the temperature of the discharged cooling water will increase proportionally. As a result, the maximum discharge temperature of the cooling water can be reached more frequently, which could see a more frequent restriction of the maximum thermal loads to be discharged on a daily basis, cf. the conditions included in the existing permit of KCD, with summer as the most sensitive period. These effects may have a significant impact on the overall performance of KCD. Due to the expected decrease in the flow rate of the Scheldt due to climate change, the impact of the thermal load of KCD in the Scheldt is expected to increase. The area in which the temperature rise exceeds 3°C may extend beyond the breakwater, especially around the turn of the low water tide. It is then possible that the heat barrier formed in the Scheldt during certain periods in the tidal cycle is more difficult or even impossible for certain aquatic organisms to pass. The increase in the size of the heat plume will be most pronounced in summer. The significance of the negative effects of climate change on the one hand on the functioning of KCD and on the other hand on the thermal pollution in the Scheldt with derived secondary effects on biodiversity depends on the evolution of climate change. In view of climate adaptation, a possible future scenario is that KCD will have to expand its cooling capacity in order to maintain the same production capacity as in the baseline situation and the operational phase 2015-2018. This means more losses due to evaporation and an increase in the thermal load discharged into the Scheldt.

3.2.2.1.5 Assessment of impacts on the status of bodies of water - Test under KRW Annex V

3.2.2.1.6 Estimation of the probability of effect - test for further analysis

In accordance with the interim guidelines for the assessment of impacts on the status of water bodies (Coordinating Committee on Integrated Water Policy, 2019), a number of criteria are used to determine whether further analysis is needed:

- Hydromorphological changes: The project does not relate to hydromorphological changes to the water body → no further analysis is needed
- Discharges: the project relates to a class 1 discharge of industrial waste water → further analysis is indicated
- Changes to groundwater: the project does not relate to changes to groundwater → no further analysis needed

Further analysis is needed into the effects of the discharge.

3.2.2.1.7 Analysis of the effects of the discharge

The physico-chemical elements to be analysed are the following, in the case of transitional water:

- dissolved oxygen
- temperature
- pH
- nitrate+nitrite+ammonium

The following elements have to be analysed (they must be analysed to predict the effects on the biological elements, but are not taken into account for the assessment of the condition):

- BOC
- COC

In addition, an assessment should be carried out for 'specific pollutants which contribute to determining the ecological status' and 'polluting substances which contribute to determining the chemical status' for those parameters for which, in their current state, the environmental quality standard is exceeded or whose concentration would increase. Finally, the biological quality elements should be assessed, if possible.

Physico-chemical elements that determine the biological elements:
For dissolved oxygen, it is assumed that no deterioration will occur if the standards for biological and chemical oxygen demand are met. If the physico-chemical elements show a deterioration, it is assumed that there will also be an effect in the biological quality elements and that the status of the body of water will deteriorate.

The average discharge is pH neutral, no changes to the pH are expected due to the present project.

The impact of the discharge on the temperature of the Scheldt is discussed in detail in paragraph 3.2.2.1.4. In conclusion, there is no deterioration in temperature for the entire body of water as a result of the thermal discharge of the KCD.

For the parameters nitrite+nitrate+ammonium, BOC and COC, the impact of the discharge was calculated as negligible; therefore, no change in the status of the water body is expected.

Specific pollutants that help to determine the ecological status:
Uranium is not a relevant parameter because it is not discharged by the KCD. The calculated impact for the parameters arsenic and boron is negligible; therefore, no deterioration is expected for the 'evaluation of the specific pollutants that help determine the ecological status'.

Pollutants that determine the chemical status:
In the current state, the following parameters exceed the basic environmental quality standard: PAHs, polybrominated diphenyl ether, tributyltin, perfluoroctane sulfonic acid, heptachlor epoxide and total mercury.

For the mercury parameter, the impact of the discharge was calculated. The impact is negligible. The other parameters are not discharged by the KCD. Consequently, no deterioration is expected for the 'pollutants that determine the chemical status'.

Biological quality elements:
The impact on the biological quality elements cannot be determined quantitatively. Based on the assessments in the Biodiversity section of the impact of water intake, cooling water discharge and chemical discharge on aquatic organisms in the Scheldt, no deterioration of the biological quality elements in the entire water body is expected.

Conclusion:
It is not expected that the implementation of the project will lead to deterioration or jeopardise the objectives set for the entire body of water.

3.2.2.2 Operational phase in the future situation (period 2019-2025)

The water supply, the infiltration and discharge characteristics and the emissions to the water system will not differ significantly in the LTO situation, as explained above, from the emissions in the baseline situation. There are no additional effects of the LTO situation compared to the baseline.

3.2.2.3 Post Operational Phase (period 2025-2029)

The Post Operational Phase or POP of KCD starts in 2025 and ends in 2028. After the POP period, the decommissioning of the reactors can start when the necessary permits have been obtained. The POP period consists of 3 phases in which KCD gradually evolves from a nuclear power plant over, the wet storage of irradiated fuel to a building with radioactive waste to be processed. The activities taking place during the POP period are all activities covered by current permit. Specifically for the production of waste water, process circuits are drained for treatment in the Water and Waste Treatment Unit (WAB) or disposed of for external processing, as would be done for an outage.

Conclusion: The main characteristics of the POP period are that this period is an extension of the current KCD operation (= with current KCD processes ongoing) and that the processes will run in accordance with the current permit. Emissions to the water system will be similar or lower than in the baseline situation.

No difference is expected in effects between a POP in 2015-2019 versus 2025-2029.

3.2.2.4 Zero alternative

3.2.2.4.1 Potable water supply

Under the alternative situation no-LTO, a decrease in consumption of both mains water and Scheldt water is expected.

However, the consumption of mains water is not expected to decrease drastically. After all, the initiator did not notice any drastic drop when a unit was out of service. Only the consumption of mains water for the steam cycle is expected to decrease slightly.

The Doel 1 and 2 units will no longer be in operation, so the cooling circuits of these units will no longer be used. The consumption of Scheldt water as cooling water will therefore also decrease and is expected to amount to approximately 704 million m³ annually. This calculation was made by the initiator on the basis of the expected number of operating hours and the average hourly flow rate of the pumps at the intake point for Doel 3/4. The Scheldt water consumption in the alternative situation non-LTO amounts to approx. 60% of the Scheldt water consumption in the baseline situation.

3.2.2.4.2 Change of infiltration and discharge characteristics

Under the alternative situation no-LTO, no physical interventions are scheduled compared to the baseline situation. In the situation under the basic project, there is a limited increase in paving. The effect groups due to changes in the discharge of surface water, changes in the structure of watercourses, changes in infiltration of rainwater, loss of quality of surface water or groundwater or changes in groundwater flow are not relevant in the Zero alternative or for the base project.

Considering the considerable amount of paved surface of KCD, the frequency and volume of flooding of the collection wells for sanitary waste water from the site to the Scheldt in the baseline situation, the fact that the environmental quality standards for N, P and COC for the Scheldt are not met in the baseline situation and the expected periods of intense rain in winter and heavy thunderstorms and water shortages in summer due to climate change, the Water section recommends examining the feasibility of the following measures at concept level and according to the Best Available Technology:

- Source-specific measure: for new projects, analyse the impact of disconnecting rainwater from sanitary wastewater and the possibilities for reuse of rainwater, infiltration or buffering according to BAT. The climate-scaled showers must be taken into account. The high-impact scenario provides a good frame of reference for making KCD more climate-proof;
- End-of-pipe measure: analysis of the installation of additional collection volume for sanitary waste water according to BAT with the aim of reducing overflow.

3.2.2.4.3 Surface water quality

The concentrations of pollutants in the discharged sanitary and industrial waste water are expected to be the same as in the baseline situation. However, no drastic decrease is expected for the production of sanitary and industrial waste water. After all, the initiator did not notice any drastic drop when a unit was out of service. Only the consumption of mains water for the steam cycle is expected to decrease slightly. It is not possible to quantify this decrease.

The concentrations of pollutants in the cooling water, including temperature and chlorides, are expected to be equal to those of the baseline situation. The Doel 1 and 2 units will no longer be in operation, so the cooling circuits of these units will no longer be used. The consumption of Scheldt water as cooling water will therefore also decrease and is expected to amount to approximately 704 million m^3 annually. This calculation was made by the initiator on the basis of the expected number of operating hours and the average hourly flow rate of the pumps at the intake point for Doel 3/4. The Scheldt water consumption in the alternative situation non-LTO amounts to approx. 60% of the Scheldt water consumption in the baseline situation. The discharged pollutant loads and thermal loads of the cooling water are therefore also expected to decrease to approx. 60% of those in the baseline situation.

To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

3.2.2.4.4 Thermal impact of the discharge of cooling water

The thermal load of the cooling water on the Scheldt is expected to decrease to approx. 60% of the baseline situation. The size of the heat plume in the Scheldt is therefore also expected to be lower. This may have a positive impact, especially in the light of climate change as described in the assessment of the thermal impact of the cooling water discharge during the operational phase 2015-2018 of the basic project.

The significance of this positive effect depends on the degree of shrinkage of the heat plume relative to the baseline situation, which is difficult to estimate with current data, and also depends on the evolution of the expected climate effects.

3.2.2.5 Cross-border effects

At the Dutch border, at a distance of about 3.4 km from the point of discharge of KCD, the influence of the discharge of the cooling water can at most be considered slightly negative (-1). This is based on the 5 monitoring campaigns of the temperature impact of Doel's cooling water on the Scheldt (Arcadis, 2012). This temperature increase will slowly decrease further downstream on Dutch territory.

3.2.3 Monitoring

This EIR incorporates the monitoring measure cf. the recommendation of INBO (Van den Bergh et al., 2013), namely that Engie provides routine monitoring of the spatial-temporal evolution of the temperature gradient between Hansweert and Antwerp. Given the fairly general availability of (thermal) satellite imagery and the experience with it abroad, this method may also be applied in the Zeeschelde to monitor the temperature gradient in the wider environment of KCD. In this way, changes in the cumulative thermal load on the Zeeschelde can be better visualized and detected.

For the parameters of ammonium, B, Sb, Co, Mo, Se, Sn, Ag, Ba, Tl, Ti, V, Be, Te, anionic, non-ionic and cationic surfactants, the measurements on the sanitary waste water are performed inconsistently or the detection limit of the measurements is higher than the discharge standard. As a result, it is not possible to make well-founded statements about the concentrations and reaching discharge standards for these parameters. KCD should measure these parameters in the sanitary effluents consistently where the detection limits of the analytical methods are lower than the relevant discharge standards.

For the parameters Co, Ag, Tl, V, Be, anionic, non-ionic and cationic surfactants and sodium fluorinate, the measurements on the industrial effluent are carried out inconsistently on industrial waste water, for the years 2013 and/or 2014 or the detection limit of the measurements is higher than the discharge standard. As a result, it is not possible to make well-founded statements about the concentrations and reaching discharge standards for these parameters. KCD should measure these parameters in the industrial waste water consistently where the detection limits of the analytical methods are lower than the relevant discharge standards.

For the faecal coliforms parameter, the measurements are performed inconsistently for the years 2013 and/or 2014. As a result, it is not possible to make well-founded statements about effluent concentrations and pollutant loads and meeting discharge standards for these parameters. KCD should measure these parameters in the cooling water consistently where the detection limits of the analytical methods are lower than the relevant discharge standards.

To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

3.2.4 Mitigating measures and recommendations

No mitigating measures are set from the Water section.

The Water section makes the following recommendations:

- To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.
- Considering the considerable amount of paved surface of KCD, the frequency and volume of flooding of the collection wells for sanitary waste water from the site to the Scheldt in the baseline situation and in the operational phase 2015-2018, the fact that the environmental quality standards for N, P and COC for the Scheldt are not met in the baseline situation and in the operational phase 2015-2018 and the expected periods of intense rain in winter and heavy thunderstorms and water shortages in summer due to climate change, the Water section recommends examining the feasibility of the following measures at concept level and according to the Best Available Technology:
  - Source-specific measure: for new projects, analyse the impact of disconnecting rainwater from sanitary wastewater and the possibilities for reuse of rainwater, infiltration or buffering according to BAT. The climate-scaled showers must be taken into account. The high-impact scenario provides a good frame of reference for making KCD-1 and KCD-2 more climate-proof;
  - End-of-pipe measure: analysis of the installation of additional collection volume for sanitary waste water according to BAT with the aim of reducing overflow.

3.3 Noise & vibrations

3.3.1 Baseline situation

The KCD has sources emitting sound to the open air that can have an impact on the environment. A distinction is made between continuous sources and sources that are only in operation for a limited period of time, such as emergency diesels and emergency pumps. Changes related to LTO may involve changes in the noise emissions of KCD, both in terms of total noise emissions and in terms of source-specific noise emissions.

To determine the ambient noise, measurements were carried out in 2009 and in 2014 at 3 measurement points located at the plot boundary or approximately 200 m from the plot boundary. During these measurements, KCD was in operation, but of course other noise sources also influence the ambient noise (e.g. industrial installations on the other side of the Scheldt). These measurements show that the environmental quality standard is exceeded during the night at the south and especially at the north of

KCD. This is not the case for the measuring point to the west, but this measuring point is further away from other (non-KCD) industrial installations. At this last point, we see a decrease in ambient noise in 2014 compared to 2009, with the wind blowing from the industrial area.

In 2009 and 2014, the noise levels of the sources at KCD were extensively inventoried. The main sources for KCD are the two cooling towers, followed by the auxiliary coolers and then the turbine halls, fans of the bunkers and the reactor buildings.

The calculations for the situation in 2013-2014 show that the specific noise emitted by KCD, i.e. the noise generated by the installation, during the evening and night period exceeds the guide value at 2 assessment points in the Scheldt, mainly due to the noise contributed by the cooling towers. As this is greater than 10 dB(A) at one point, the operator must draw up a remediation plan for this. A remediation study was drawn up in 2010 with regard to the noise impact from the cooling towers. However, the study concluded that the possible remediation measures are not justified from an economic and safety point of view. The monitoring committee has accepted this study and the decisions.

The calculations also show that the impact of the continuous sources at KCD on ambient noise at a distance of 200 m from the plot boundary in northern, southern and western zones (agricultural area) is slightly negative, negative in the northeast and significantly negative in the east (Scheldt, nature reserve). At the level of the nearest houses (more than 200 m away), the impact is slightly negative to negligible.

The discontinuous sources, these are the emergency diesels and emergency pumps, are only briefly activated for testing and maintenance, unless of course in emergencies. Therefore, an average time-weighted impact was determined. This impact remains well below that of continuous sources. The combined impact of the continuous and discontinuous sources, which only occurs during the day, as the emergency systems are only tested during the day, does not result in exceeding the guide value (for the day), except for the 2 previously mentioned points in the Scheldt. However, the contribution of the discontinuous sources is negligible here.

It is assumed that KCD does not cause an increase in the ambient noise at the houses under consideration in the Netherlands.

3.3.2 Impact assessment

In the period 2015-2019, further measurements of the ambient noise were carried out at the three previously mentioned measurement points. The ambient noise from KCD remains relatively stable.

The noise emission of the continuous sources does not change because of LTO or the POP of units Doel 1 and 2. The noise emitted by all discontinuous sources rises by a negligible 0.2 dB(A) compared to 2013-2014. This was due to some new sources (diesel generators and diesel pumps) that were added. However, these sources were not installed because of LTO.

The work carried out as part of the adjustments for LTO in itself causes a negligible increase in ambient noise.

In general, it can be said that no distinctive noise effects are expected for the different operational phases compared to the baseline situation 2013-2014. The differences in the evaluation points are limited to less than 0.5 dB(A) for all phases of operation.

Additional mitigating measures will therefore not be formulated for the future operational phases.

3.4 Air & climate

3.4.1 Baseline situation

The air quality in the vicinity of KCD (approx. 1 km) can be determined using VMM's measuring stations. The applicable limit values for sulphur dioxide, nitrogen dioxide, fine dust, carbon monoxide and benzo(a)pyrene are met. However, the WHO advisory values are not always met, in particular for fine dust.

The KCD guided emissions - these are emissions with a measurable volume flow rate - come from various combustion systems: auxiliary steam boilers, emergency diesels and heating systems. Under normal circumstances, there are only emissions from the auxiliary steam boilers and emergency diesels when testing these systems.

Emissions can be estimated on the basis of fuel consumption (diesel or gas oil), the number of running hours and emission factors from the literature. These are carbon monoxide, nitrogen oxide, sulphur oxide and fine dust emissions. Nitrogen oxides are the main pollutant.

Unguided emissions, such as those from tanks containing aqueous solutions of ammonia and hydrazine, are not relevant due to the nature of the products (low volatility) or the adoption of emission-reduction measures.

The steam plumes from the cooling towers, which are linked to the operation of the Doel 3 and 4 power stations, contain salt as the naturally brackish Scheldt water is used. The salt deposition in the surrounding area is estimated at approx. 0.25 g/m² per month.

Due to the height of the cooling towers, the steam plumes themselves have no influence on the microclimate.

As part of its obligations as an energy-intensive facility (mainly through consumption of electricity), KCD has a conforming energy plan. By taking energy saving measures, KCD has been able to reduce the electricity consumption of the non-technical buildings.

KCD also produces an annual monitoring report of its greenhouse gas emissions. In 2014, the calculated emissions amounted to 1,411 tonnes of CO_2. As these CO_2-emissions under normal circumstances are the result of testing the combustion systems responsible for ensuring the safe operation of the nuclear systems, the level of these emissions remains fairly constant.

3.4.2 Impact assessment

The impact on air quality of the works performed as part of the LTO changes, such as the impact of dust emissions and exhaust emissions from construction site machinery and lorries, is assessed as slightly negative to negligible due to the limited scope of the work and its temporary nature.

The impact of the new diesel generators planned under LTO is negligible. The new diesel generators provided for under LTO are subject to much stricter emission limits than those for legacy systems. The impact of nitrogen oxides emissions on air quality is negligible, both when Doel 1 and 2 are in operation and in the zero alternative where diesel generators are no longer tested (after the POP).

The salt emission from the cooling towers will not change. After all, the cooling towers are only linked to Doel 3 and 4. The Doel 1 and 2 reactors are cooled using water-water cooling (not using the cooling towers). The water circulation in the cooling tower therefore remains the same regardless of the operation of Doel 1 and 2.

No mitigating measures are necessary.

The cross-border or cumulative effects are negligible.

Annual CO_2-emissions in the period 2000-2019 generally fluctuated between 1,000 and 2,000 tonnes. Direct emissions are therefore very limited. In the Zero alternative, these emissions will be even more limited.

An indirect impact can be expected, however, because if energy demand remains the same or rises, the energy requirement for the shutdown of Doel 1 and 2 power stations will have to be met in a different way. Nuclear energy is a low-carbon energy source. A recent publication by the International Energy Agency shows that without further lifetime extensions of existing nuclear power plants or new projects, an additional 4 billion tonnes of CO_2 could be emitted. According to the report, a range of technologies, including nuclear energy, will be needed for the energy transition.

It can be assumed that the indirect CO_2 emissions would be/have been higher in the Zero alternative, because if Doel 1 and 2 were to be closed down, more electricity would (and will) have to be imported from abroad, and this imported electricity would partly be generated from fossil energy sources.

Of course, these assumptions contain a great deal of uncertainty. An undesirable side-effect of extending the operation of Doel 1 and 2 could, for example, be that it discourages investment in renewable energy. However, this potential effect cannot be estimated within the scope of this EIR.

3.5 Biodiversity

3.5.1 Baseline situation

3.5.1.1 Information about the natural reserves

In the vicinity of KCD there are several valuable natural reserves and protected areas. These areas are largely located near the banks of the river Scheldt and are protected at both European and Flemish level.

3.5.1.1.1 Natura 2000 areas

At the European level, the natural structure of the delimited study area is dominated by the following Special Areas of Conservation (SPAs):

- **BE2301336 Special Protection Area - Birds (SPA-B) '‘Schorren en polders van de Beneden-Schelde’ (Salt marshes and polders of the Lower Scheldt)**. This includes the polder area on the left bank, which is currently largely occupied by the port, and a smaller area of polder area on the right bank, but also the Galgenschoor and the Groot Buitenschoor. The KCD site is surrounded by the Special Protection Area for Birds on the left bank and overlaps with it locally. As a the Special Protection Area for Birds on the left bank was taken over by port-related infrastructure (including the Deurganck dock), a great deal of nature was lost. In order to compensate for this loss of natural area, a number of areas were demarcated and set up to compensate, these are the so-called compensation areas. Near KCD, the Paardenschor, Doelpolder Noord and Brakke Kreek were created as compensation areas. Doelpolder Midden will have to be created still.
- **BE2300006 Special Protection Area - Habitats ‘Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent’ ('Scheldt and Durme estuary from the Dutch border to Ghent')**. This includes both the Scheldt stream area and the mudflats and salt marshes along the Scheldt and the Paardenschor area outside the dikes. KCD is located on the edge of the Scheldt and this Special Protection Area - Habitats.

Both Special Areas of Conservation overlap at the level of the Scheldt banks.

The Special Protection Area - Birds BE2300222 'De Kuifeend en de Blokkersdijk' and the Special Protection Area - Habitats BE2100045 ‘Historische fortengordels van Antwerpen als vleermuizenhabitat’ (Historic ring of forts of Antwerp as a bat habitat) are located more than 3 km from the KCD site. They are outside the sphere of influence of KCD's activities because they are further away from the site, in combination with the expected effects of KCD's activities on biodiversity.

On Dutch territory, the ‘Verdronken land van Saeftinghe’ (Drowned Land of Saeftinghe) is part of the Natura 2000 area 'Westerschelde & Saeftinghe' and designated as a Special Protection Area for birds and habitats (NL9803061). This area is located more than 3 km north of KCD and therefore outside the study area. Other Natura 2000 areas in the Netherlands such as the Oosterschelde, Markiezaat and Brabantse Wal are at a greater distance (> 10 km) from KCD. These areas are outside the sphere of influence of KCD's activities because they are further away from the site, in combination with the expected effects of KCD's activities on biodiversity.

3.5.1.1.2 Ramsar areas
Ramsar areas are wetlands of international importance and designated because of their importance for waterfowl, biodiversity and fish populations.

The **Galgeschoor**, **Groot Buitenschoor** and the **Schorren van Ouden Doel** are designated as Ramsar area (Ramsar no. 327). The distance of Galgenschoor and Groot Buitenschoor to KCD is 1.2 km and 2.7 km respectively; these areas are located on the right bank of the Scheldt. Schor van Ouden Doel is located next to the KCD site at less than 1 km distance and within the study area. The Ramsar areas are located near the banks of the Scheldt and overlap with the Special Protection Areas for Birds and Habitats.

3.5.1.1.3 VEN areas
The '**Slikken en schorren langs de Schelde' (mudflats and salt marshes along the Scheldt**) are designated as Large Nature Areas (GEN) (area no. 304) and are part of the Flemish Ecological Network (VEN). The KCD site borders this VEN area.

The Scheldt waterway and the adjacent mud flats and salt marshes are very dynamic due to the tidal effect and have a very high ecological value. The high natural productivity of the ecosystem has repercussions throughout the food chain both in terms of species and numbers. The salt-bracket-fresh gradient present in the tidal zones is important. The landscape-determining structure means that migratory fauna also use this route as a migration route. The riparian zones along the Scheldt form important connections between the larger nature areas (Verdronken land van Saeftinghe), the remaining large brackish water areas (Galgenschoor, Groot buitenschoor, Schor van Ouden Doel) and the more recent compensation areas with mudflats and salt marshes (Ketenisseschor, Paardenschor, Prosperpolder, Lillo-Potpolder,...) along the Scheldt. As a result, the riparian zones have an important network function. These listed zones are all part of this VEN area. The banks of the Scheldt near KCD are also part of this demarcated VEN area.

The VEN areas near the banks of the Scheldt overlap with the Special Protection Area - Birds, the Special Protection Area - Habitats and the Ramsar area.

3.5.1.1.4 Nature reserves
The **Schorren van Ouden Doel** are a recognized nature reserve (reserve no. E-110) located on the left bank of the Scheldt. It overlaps with the Special Protection Area - Birds, Special Protection Area - Habitats, Ramsar area and VEN area. The Schor van Ouden Doel is located north of the KCD site, less than 1 km away. In the further surroundings along the Scheldt there are the **Galgenschoor and Groot Buitenschoor** (reserve No. E-021), these two nature reserves are located on the right bank of the Scheldt at respectively 1.2 km and 2.7 km distance from KCD.

3.5.1.1.5 Other areas important for nature
Other important areas in the vicinity of KCD are the **Hedwigepolder** and **Prosperpolder**. The Prosperpolder is located northwest of KCD at a minimum distance of 0.9 km. The Hedwigepolder is connected to this polder and is located across the border in the Netherlands, at least 2.1 km away. Both areas belong to the cross-border intertidal area under development. These polders connect to the Verdronken Land van Saeftinghe and form a nature reserve of international significance of about 4,000 hectares.

Near KCD, the **Paardenschor**, **Doelpolder Noord** and **Brakke Kreek** were created as **compensation areas**. These areas link up with the Schor van Ouden Doel and the Hedwigepolder and have been important areas for biodiversity for several years now.

The other zones around KCD have been preserved as polder areas **(Doelpolder, Arenbergpolder**). These polder areas are part of the Special Protection Area for Birds on the left bank. In time, Doelpolder Midden can still be set up as a tidal area **(controlled reduced tidal area (GGG) Doelpolder)**, together with the meadow bird area Doelpolder Noord. As the RSIP Delimitation of the Antwerp Seaport Area - Port Development Left Bank[1] was overturned, this nature development cannot continue as planned for the time being.

The Scheldt and its immediate surroundings are a **faunistically important area**. According to the 'Vlaamse risicoatlas vogels-windturbines' (Flemish risk atlas bird-wind turbines) (INBO, 2011) various breeding areas, meadow bird areas, roosting areas and bird sanctuaries are located in the mudflats and salt marshes, polders and docks. The Scheldt is an important migratory route for birds, many species visit the area to come together or wintering. Around the Doel site there are many birds flying over, to and from their roosts, resting grounds or feeding grounds. KCD is almost completely enclosed by the Beveren Linkeroever Polders resting ground. Other important areas are the Zeeschelde Nederlandse Grens - Lillo (resting ground), Linkeroever (breeding ground), Galgeschoor and the Groot Buitenschoor (breeding and resting ground), Kanaaldok B2, Kanaaldok B3, Zandvliet lock, Doeldok and Deurganckdok.

Bird migration routes avoid the site of the KCD in itself, but around the site there is a heavy traffic of sleep, food and seasonal migration. The cooling towers of KCD have been a breeding site for peregrine falcons since 1996 due to the presence of a nesting box. Below is an overview of how many peregrine falcons were born at this breeding site in the period 2013-2019:

- 2013: 1
- 2014: 3
- 2015: 4
- 2016: none
- 2017: 4
- 2018: 3

[1] On Friday 12 May 2017, the Council of State voided the April 2013 Regional Spatial Implementation Plan (RSIP) delimitation of the Antwerp seaport area for the left bank of the Scheldt. As a result, the expropriation plans for the hamlets of Ouden Doel and Rapenburg and for the nature areas of Prosperpolder Zuid phase 1, Doelpolder Midden, Nieuw Arenberg phase 1 and Grote Geule have been dropped. On Right Bank, the RSIP remains in full force.
The Council of State has said that port development and nature development on the left bank of the Scheldt are inextricably linked. Since the Council already voided the RSIP for port development on 20 December 2016, it believes that the RSIP for nature should now also be voided. This means that all the areas designated as nature in the RSIP (Prosperpolder Zuid phase 1, Nieuw Arenberg phase 1, Doelpolder Midden en Grote Geule) now revert back to the spatial zoning in the Regional Plan of 1978. Large parts of the left bank of the Scheldt now again have the mixed-use agriculture / port expansion. However, the Council had already made an exception for the western part of the Waasland Logistics Park, and now confirms this, so that the port's destination will remain at that location.

- 2019: none

3.5.2 Impact assessment

3.5.2.1 Operational phase of the project between 2015-2018

3.5.2.1.1 LTO works

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1).

3.5.2.1.1.1 Eutrophication and acidification due to atmospheric deposition

Emissions from exhaust gases from construction site machinery and trucks (combustion of fossil fuels and including CO, CO_2, unburnt hydrocarbons, NOx, SO_2 and particulate matter ($PM_{2.5}$ and PM_{10}) occurred during the work on LTO modifications.

The share of emissions from construction site machinery and site traffic varied from day to day, and was considered rather small compared to current emission sources at the site and in the surrounding area such as (shipping) traffic. The acidifying and eutrophic due to the construction site machinery and site traffic is not assessed as significantly negative for the habitats around KCD, taking into account its temporary nature.

3.5.2.1.1.2 Rest disturbance

It follows from the Noise Section that the work carried out as part of the adjustments for LTO in itself caused a negligible increase in ambient noise. The rest disturbance to fauna is therefore considered to be negligible.

3.5.2.1.2 Eutrophication and acidification due to atmospheric deposition

Eutrophication and acidification due to atmospheric deposition as a result of the operation of KCD is assessed as follows compared to the situation without the operation of KCD:

- **Nitrogen deposits** in the operational phase of KCD in the future situation is max. 0.071 kg N/(ha.year), which is lower than 5% of the critical N deposition values of the European habitat types located in the vicinity of the site. It can be concluded that the nitrogen deposits of KCD in the present project do not have a significant negative effect on eutrophication of the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mudflats and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'.
- It can be concluded that the **acidifying deposits** of KCD assessed in the present project do not have a significant negative impact on the ecosystems in the study area, since the acidifying deposition of KCD is maximum 5.06 Zeq/ha.year, which is lower than 5% of the critical deposit rates for acidifying deposits of the ecosystems in the vicinity of the site. Therefore, no significant negative effects are expected from acidification as a result of the operational activities of the KCD on the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mud and salt marsh vegetation in the (partly overlapping) VEN area 'Slikken en schorren langsheen de Schelde'.

3.5.2.1.3 Rest disturbance

The rest disturbance due to the operation of KCD in the 2013-2014 baseline situation, also equal to the rest disturbance in the 2015-2018 operational phase, compared to the situation without the operation of KCD can be assessed as follows:

- To the east of the KCD, the 55 dB nuisance contour extends into the Special Protection Area - Birds
  'Schorren en polders van de Beneden-Schelde', also designated as the VEN area 'Slikken en schorren langs de Schelde' and as a Ramsar area. It can be concluded that these reed beds and mudflats along the banks of the Scheldt, are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. Rest disturbance due to the operation of KCD along the reed zones and mudflats on the banks of the Scheldt, near the KCD, is assessed as negative. The 50 dB and 45 dB nuisance contours do not extend to the Galgenschoor across the Scheldt.
- North of the KCD the 50 dB and 45 dB nuisance contours do not reach the protected nature reserve 'Schor Ouden Doel' (negligible effect).
- To the west and south of KCD, the nuisance contour of 50 dB is largely limited to the KCD site itself and there is only a slight overlap with the Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'. The 50 dB nuisance contour does not overlap with the VEN area 'Slikken en schorren langs de Schelde' here. The 45 dB nuisance contour has limited overlap with the Special Protection Area - Birds "Schorren en polders van de Beneden-Schelde" and with the VEN area "Slikken en schorren langs de Schelde". The disturbance caused by the operation of KCD in the polder areas to the west and south of KCD is assessed as a slightly negative effect.

3.5.2.1.4 Water intake

- KCD extracts cooling water from the Scheldt via a water intake that is divided into two separate components: one for cooling the Doel 1 and Doel 2 units and another, commissioned in 1991, for Doel 3 and Doel 4. The water is always first passed over a sieve to filter out any objects to prevent obstruction of the pipes. However, for the two intakes, this is done in a different way.
- For the Doel 1 and 2 cooling water intake, mechanical treatment takes place outside the dike, at the level of the water intake, by means of grids on the inlet. Fish and crustaceans cannot enter the cooling water circuit in this way. Therefore, no mortality of fish or crustaceans will be observed at this intake.
- For Doel 3 and 4, the set-up is different. A cooling water intake system was fitted, in which the water was first gravitated from the Scheldt to a collection pit on the site itself. From that catchment, the water is then transported over a system of rotating belt filters. In 1997, a fish protection system was installed at the water intake with a fish-friendly filter system and a drain channel. Sound waves keep fish away from the intake. Because of this noise, the fish are deterred and fewer of them end up in the water intake. Based on the monitoring carried out by KU Leuven (Maes *et al.*, 1996), where it was found that the daily catch for fish and crustaceans without measures was about 22,437 and 50,248 individuals respectively, it can be stated that an average of 1,010 fish die daily and almost no crustaceans as a result of the presence of the water intake of

Doel 3 and 4 with the fish protection system. Compared to the fact that the KU Leuven study (Maes *et al.*, 1996) shows that there are approximately 18 million fish and 7 million crustaceans that pass by the plant per hourthe impact has been reduced to a negligible level thanks to the various measures taken. On this basis, it can be said that no significant negative effects are to be expected with regard to mortality of fish and crustaceans at the level of water intake. The capacity of the water intake points in the Scheldt will not be changed by the project.

3.5.2.1.5 Discharge of cooling water

The discharge of cooling water is assessed as follows, compared to the situation without the operation of KCD:

- The most sensitive animal group for thermal discharges are fish. The lethal temperature for fish is highly species-dependent. Fish generally show no effect in the temperature range from 10 to 22°C. Between 22 and 28 to 30°C is a stress zone and lethal consequences occur only above 28°C, due to significant stress. On this basis, it can be stated that under average conditions and virtually throughout the entire year, no significant negative effects on fish fauna are to be expected. Only the most sensitive species will avoid the zone closest to the point of discharge by swimming away from it. However, species-specific data on the avoidance behaviour and startle reactions of fish with respect to cooling water discharges have not been found in the literature, hence the assessment is mainly based on lethal temperatures. In the area within the breakwater, from 850 m downstream of the point of discharge, the temperature falls below 10°C in winter and spring (Arcadis 2012 monitoring campaigns), which means that the low temperature that fish species such as ruffe and smelt need to induce their reproduction is reached.
- Sampling of the aquatic organisms within the cooling water plume of KCD by INBO in 2013 (Breine & Van Thuyne) showed that fish are more likely to be found in the area within the breakwater with a higher water temperature. In addition, the area is less dynamic than outside the breakwater. The presence of sea bass, a warmth-loving marine species, demonstrates that this species uses the area within the breakwater as a winter refuge. Sole holds up within and near the breakwater area. Some species use the warmed up area within the breakwaters to reach adulthood. There is therefore an indication that there is an increased abundance of heat-loving native species (sea bass and sole) within the breakwater. Finally, discharge of cooling water can be important for the survival of thermophilic exotic species. Sampling of the aquatic organisms within the cooling water plume of the KCD by INBO in 2013 (Breine & Van Thuyne), showed no marked presence of exotic species in the area within the breakwater and there is no increased abundance of exotic species within the breakwater.
- Based on the previous impact discussion, the impact of the KCD's cooling water discharge on the aquatic communities in the Lower Scheldt is not considered to be considerably negative.

3.5.2.1.6 Discharge of chemical substances

During the operation of KCD, the following effluents are produced: sanitary wastewater, industrial wastewater and cooling water. The discharge of nutrients into the Scheldt can cause eutrophication. The discharge of hazardous materials into the Scheldt can cause ecotoxicological effects:

- Eutrophication:

  - For the nutrient parameters nitrate+nitrite+ammonium and orthophosphate an annual average negligible contribution is calculated in the Water Section, compared to the situation without operation of KCD. Therefore, no significant eutrophying impact is expected on an annual average basis from the discharge of the KCD to the Scheldt. In the Water section, frequent operation of the sanitary waste water collection wells was found. Although the load is rather limited, these operations can create peaks of nutrient concentrations in the Scheldt at the level of KCD, in the area within the breakwater where the discharge of the sanitary and industrial wastewater and cooling water of the KCD takes place.
  - It can be assumed that the frequent operation of the sanitary waste water collection wells of KCD contributes to a limited extent to the problem of eutrophication in the Scheldt, alebit locally at the discharge point of the KCD in the area within the breakwater. However, to what extent this leads to an increase in algal blooms and a reduction in visibility for predatory fish, a shift in the species composition of phytoplankton, and an increase in the biomass production of the higher trophic levels in the area within the breakwater, is not known. The cumulative impact of the physical characteristics (tidal dynamics, residence time, turbidity, depth) and of the temperature increase of the area within the breakwater, within which the discharge of the sanitary and industrial wastewater and cooling water from the KCD takes place, on the degree of eutrophication is also unknown. Van Damme et al. (2003) and Brys et al. (2006) state that the phytoplankton communities in the brackish zone do not allow the ecological status to be assessed. A full analysis of the phytoplankton communities is thus not considered meaningful for the assessment of the effects in the EIR. In order to reduce the operation of the sanitary waste water collection wells of KCD, the Water section recommended looking into the feasibility of disconnecting the rainwater system from the sanitary wastewater system (source-based measure) and the possibility of installing an additional collection volume for sanitary wastewater (end-of-pipe measure) at concept level and according to the Best Available Techniques.
- Ecotoxicological effects:
  - Sodium hypochlorite (NaOCl) is added to the cooling water to prevent biofouling. Biofouling is the process by which mainly sessile organisms, such as oysters, mussels, etc. attach themselves to the inlet and outlet pipes of, among other things, cooling water systems. The addition of sodium hypochlorite NaOCl should counteract this biofouling.
  - The NaOCl reacts to form chlorides. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). Active chlorine is considered to be an acutely toxic substance. For active chlorine, the concentration at which fish are not affected appears to be below 1 µg/l. Active chlorine is not very persistent and will disappear in surface water fairly quickly (the degradability has an order of magnitude of minutes). However, the conversion rate is impacted by many factors (temperature, degree of mixing in surface water, reducer content) (Berbee, 1997). The levels of active chlorine in KCD's discharged cooling water are below 100 µg/l. It can be concluded that at times of discharge of active chlorine, acute toxicological effects for aquatic organisms can occur locally around the discharge point for a short period of time (<u>slightly negative effect</u>).
  - Currently, the dosing of NaOCl at KCD is based on the analysis of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on the control of biological growth on sample plates in the cooling towers and weight measurements of the

gasket. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended in the Water section to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

3.5.2.2 Operational phase in the future situation (period 2019-2025)

The impacts of eutrophication and acidification, resting disturbance, water capture, cooling water discharge, and chemicals will not be significantly different in the LTO situation, as explained above, compared to the baseline situation. There are no additional effects of the LTO situation compared to the baseline.

3.5.2.3 Post Operational Phase (period 2025-2029)

The Post Operational Phase or POP of KCD starts in 2025 and ends in 2028. After the POP period, the decommissioning of the reactors can start when the necessary permits have been obtained. The POP period consists of 3 phases in which KCD gradually evolves from a nuclear power plant over the wet storage of irradiated fuel to a building with radioactive waste to be processed. During the POP period, only activities covered by the current permit will take place.

Conclusion: The main characteristics of the POP period are that this period is an extension of the current KCD operation (= with current KCD processes ongoing) and that the processes will run in accordance with the current permit. Air, noise and water emissions and the derived effects on biodiversity will be similar or less than in the baseline situation.

No difference is expected in effects between a POP in 2015-2019 versus 2025-2029.

3.5.2.4 Zero alternative

3.5.2.4.1 Eutrophication and acidification due to atmospheric deposition

The maximum nitrogen deposition is 0.035 kg N/(ha.year) for the KCD emissions considered in the zero alternative, which is less than 5% of the critical deposition values for N deposition of the European habitat types located in the vicinity of the site. The modelled contour of nitrogen deposition does not reach the mudflats and salt marshes along the right bank of the Scheldt.

It can be concluded that the nitrogen deposits of KCD assessed in the zero-alternative of the present project do not have a considerably negative effect on the eutrophication of the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mudflats and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'.

The maximum nitrogen deposition of KCD in the Zero alternative is 2.507 Zeq/(ha.year), which is less than 5% of the critical deposition rates for acidifying deposition of the European habitat types located in the vicinity of the site.

It can be concluded that the acidifying deposits of KCD assessed in the Zero alternative of the present project do not have a considerably negative impact on the ecosystems in the study area. Consequently, no substantial negative effects are expected from acidification as a result of KCD's activities on the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and from the mud and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'.

3.5.2.4.2 Rest disturbance

Rest disturbance due to the operation of KCD in the Zero alternative can be assessed as follows:

- To the east of the KCD, the 55 dB nuisance contour extends into the Special Protection Area - Birds
  'Schorren en polders van de Beneden-Schelde', also designated as the VEN area 'Slikken en schorren langs de Schelde' and as a Ramsar area. It can be concluded that these reed beds and mudflats along the banks of the Scheldt, are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. Rest disturbance due to the operation of KCD along the reed zones and mudflats on the banks of the Scheldt, near the KCD, is assessed as negative. The 50 dB and 45 dB nuisance contours do not extend to the Galgenschoor across the Scheldt.
- North of the KCD the 50 dB and 45 dB nuisance contours do not reach the protected nature reserve 'Schor Ouden Doel' (negligible effect).
- To the west and south of KCD, the nuisance contour of 50 dB is largely limited to the KCD site itself and there is only a slight overlap with the Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'. The 50 dB nuisance contour does not overlap with the VEN area 'Slikken en schorren langs de Schelde' here. The 45 dB nuisance contour has limited overlap with the Special Protection Area - Birds "Schorren en polders van de Beneden-Schelde" and with the VEN area "Slikken en schorren langs de Schelde". The disturbance caused by the operation of KCD in the polder areas to the west and south of KCD is assessed as a slightly negative effect.

3.5.2.4.3 Water intake

The Doel 1 and 2 units will no longer be in operation, so the water intake and cooling systems of these units will no longer be used. As no mortality of fish or crustaceans has been observed at the cooling water intake of Doel 1 and 2 due to the presence of grids on the inlet, no changes are expected for the impact of the water capture on the organisms in the Zeeschelde near KCD in the zero alternative (= the no-LTO situation).

3.5.2.4.4 Discharge of cooling water

The thermal load of cooling water on the Scheldt is expected to decrease by about 60%. The size of the heat plume in the Scheldt is therefore also expected to be lower. This can have a positive impact on the communities of phytoplankton, zooplankton, macro-invertebrates and fish within the area of the breakwater, especially in the light of climate change as described in the assessment of the thermal impact of the cooling water discharge during the operational phase 2015-2018 of the basic project.

The significance of this positive effect depends on the degree of shrinkage of the heat plume relative to the baseline situation, which is difficult to estimate with current data, and on the evolution of the expected climate effects.

3.5.2.4.5 Discharge of chemical substances

The concentrations of pollutants in the discharged sanitary and industrial waste water are expected to be the same as in the baseline situation. However, no drastic decrease is expected for the production of sanitary and industrial waste water. After all, the initiator did not notice any drastic drop when a unit was out of service. Only the consumption of mains water for the steam cycle is expected to decrease slightly. It is not possible to quantify this decrease. The Zero alternative will have the same effects on eutrophication as the baseline project.

The concentrations of pollutants in the cooling water, including temperature and chlorides, are expected to be equal to those of the baseline situation. In the Zero alternative, the same possible ecotoxicological effects will occur as in the basic project. To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended in the Water section to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

3.5.2.5 Cumulative effects

The following plans/projects may be relevant regarding cumulative effects with the operation of KCD:

- Sigma plan
- Doelpolder Noord
- Hedwigepolder and Prosperpolder
- Creation of the GGG Doelpolder

The construction phase of the above plans/projects will cause noise disturbance at the level of KCD, which may lead to cumulative noise disturbance due to the operation of KCD. The information currently available on the above plans/projects, does not allow for this cumulative noise disturbance to be quantified or assessed.

The operational phase of the above plans/projects is not expected to have any cumulative effects on biodiversity due to the operation of KCD.

3.5.2.6 Cross-border effects

At the Dutch border, at a distance of about 3.4 km from the point of discharge of KCD, the influence of the discharge of the cooling water can at most be considered slightly negative. This is based on the 5 monitoring campaigns of the temperature impact of Doel's cooling water on the Scheldt (Arcadis, 2012). This temperature increase will slowly decrease further downstream on Dutch territory.

3.5.3 Monitoring

No monitoring measures are considered necessary.

3.5.4 Mitigating measures and recommendations

No mitigation measures are considered necessary.

3.5.5 Knowledge gaps

No literature data have been found on the temperature at which a flight reaction occurs in fish as a result of a temperature change, therefore the EIR considered the impact assessment with respect to the lethal temperature.

No full analysis of phytoplankton communities is available. Van Damme *et al.* (2003) and Brys *et al.* (2006) state that the phytoplankton communities in the brackish zone do not allow the ecological status to be assessed. A full analysis of the phytoplankton communities is thus not considered meaningful for the assessment of the effects of the temperature increase, as a result of the discharge of cooling water and the operation of the sanitary waste water collection wells of KCD in the EIR.

3.6 Landscape, architectural heritage & archaeology

3.6.1 Baseline situation

The KCD site is an important landmark in the open and flat polder landscape, from all directions, mainly because of the 168 meter high cooling towers, which dominate the view of the power station. The closer you get to the power station, the more the typical dome-shaped reactor buildings appear as landmarks. The cooling towers and the entire nuclear power plant are a beacon in the landscape. The electricity produced is transported via overhead lines, both in a southern and a northern direction.

From the polder, the harbour landscape behind is visible. However, the KCD site does not completely merge with the industrial background. The distances to the right bank or to the Deurganck dock - the nearest industrial zones - are too large.

Yhe open polders contrast sharply with the harbour and industrial buildings. The open agricultural land is bordered by planted dikes and the Scheldt polders are home to small villages and hamlets. The dykes are a very typical feature of this landscape with a high relict value and they are also home to valuable nature elements. The most important landscape elements of the polders are the dikes, ditches and brooks.

The 'Slikken en schorren van Oude Doel' (mud flats and salt marshes of Oude Doel), which are located near and downstream of the KCD, are listed as a cultural-historical landscape.

There is scattered architectural heritage in the vicinity of the KCD. This is mainly farms and houses. Also the school, presbytery, parish church, train station and windmill of Doel have been identified in this architectural heritage inventory.

KCD's site is surrounded in the north and east by the landscape units 'Brackish water marshes along the Scheldt, north of Antwerp' (Brakwaterschorren langsheen de Schelde ten noorden van Antwerpen).

No known archaeological traces have ever been found near KCD. The original lands (polder, mud flats and salt marshes) on the KCD site were raised using dredged sediment in the 1960s. There may be archaeological traces underneath these elevations.

3.6.2 Impact assessment

The impact of the works that have taken place in the context of the adjustments for LTO and the operational phase of KCD in the future situation can be assessed as negligible for the Landscape, architectural heritage & archaeology section.

After all, the works and the new installations are largely shielded by the existing buildings and dikes or fit into the current industrial context on the site. The excavation work was limited to the elevated area, so that there was no disruption of any archaeological heritage present. There is no other heritage within the site that could be impacted.

No acid rain due to air pollution with an impact on valuable heritage and elements of the landscape is expected. The new diesel generators provided for under LTO are subject to much stricter emission limits than those for legacy systems. In addition, low-sulphur diesel is used. The emissions of the new systems will be negligible compared to the total emissions of the Doel 1 and Doel 2 engines.

The visual impact on the landscape of KCD will not change during the Post Operational Phase. The diesel generators will continue to run as in the baseline situation. However, the emissions are too limited to give rise to a disruption of landscape relics and heritage as a result of acidification.

In the Zero alternative, no interventions took place in the context of the LTO of Doel 1 and 2. As far as the Landscape, architectural heritage & archaeology section is concerned, it can be concluded that there is no difference between the POP in 2015 (= Zero alternative) or in 2025.

No mitigating measures or recommendations are necessary for the Landscape, architectural heritage & archaeology section.

No cross-border or cumulative effects occur for the Landscape, architectural heritage & archaeology section.

3.7 People - Health and Safety

3.7.1 Baseline situation

The environmental health stressors to be investigated are noise pollution, shade of the water vapour plume, risk of infection by Legionella and psychosomatic aspects. Safety and the consequences of non-nuclear accidents are also discussed.

The environmental quality standard for ambient noise during evening and night is already slightly exceeded if KCD is not in operation. KCD itself contributes less than 2 dB(A) to the ambient noise during normal operation at the level of the nearest houses. This difference is not audible. Due to the fact that the environmental quality standard has already been exceeded, we assess the contribution as slightly negative.

The white water vapor plume of the cooling towers can have an impact on the number of hours of sunshine from a short distance (approx. 3 km). However, the reduction in the number of hours of sunshine is negligible compared to natural variations. In addition, most houses are located at a greater distance from the power station. Therefore, the impact is assessed as slightly negative to negligible.

Due to the presence of open cooling towers, the legionella decree applies to KCD. The legionella bacteria can cause severe pneumonia. The cooling towers that use Scheldt water do not pose a risk of legionella contamination due to the high salt content. Only the Doel 1 and 2 auxiliary cooling towers are fed with mains water. However, provided the legionella management plan is applied, the risk of contamination with legionella from the cooling towers is negligible.

Psychosomatic complaints are related to risk perception. There are no specific data available on the risk perception of the Doel nuclear power plant. However, there are data on the general attitude of the population towards nuclear energy and the nuclear sector. Surveys show that 53% are concerned about the risks of a nuclear accident. Furthermore, 52% agree that the nuclear reactors in Belgium are operated in a safe way. 14% disagree. Given the relatively high confidence in the safe operation of nuclear reactors in Belgium, the high risk perception of nuclear reactor accidents is therefore somewhat surprising. People may also be concerned about accidents abroad with implications for Belgium.

KCD contains hazardous substances which, given their quantities, could lead to a (non-nuclear) major accident. These are gas oil, hydrogen, hydrazine, potassium chromate and all kinds of substances in small packages in warehouses. The external risk to human beings (i.e. the risk of death of persons outside the facility) and the environmental risk in case of major accidents that can occur with KCD were evaluated.

The maximum impact distances of the events with a 1% site-related risk of death do not extend beyond the boundaries of the site. The risk of death outside the site as a result of a major accident of KCD is therefore considered to be completely negligible.

The substances hazardous to the environment are hydrazine and gas oil. A qualitative environmental risk analysis was carried out for the systems containing these substances. This is a qualitative analysis of causes and consequences. The analysis shows that due to the measures taken to prevent releases of hydrazine and gas oil and to limit consequential damage to the environment, the remaining environmental risk is negligible.

3.7.2 Impact assessment

No LTO changes are being made that have a significant impact on health-relevant environmental stressors.

The noise impact, the change in sunshine duration, and the risk perception of KCD will not change due to the longer operation of Doel 1 and 2 or due to the adjustments needed for the LTO. If Doel 1 and 2 were to be shut down, the auxiliary cooling towers of these power stations would no longer require any cooling water, so that the risk of Legionella would be completely eliminated after the POP. However, as the risk was already considered negligible, on balance this effect is not significant.

In the Post Operational Phase of Doel 1 and 2, a number of hazardous substances would be removed either at the beginning or at the end of this process. The external risk to human beings and the environment with regard to systems containing these substances will then also decrease. It can be concluded that the external risk to human beings and the environment as a result of accidents involving hazardous substances during or after the POP of Doel 1 and 2 (= zero alternative) will be slightly lower than in the LTO scenario and negligible in both cases.

The effects in terms of noise, shade of the water vapour plume and risk of infection for Legionella are negligible in the Netherlands given the distance to KCD.

However, people in the Netherlands may also be concerned about the risk of nuclear accidents at KCD. The risk perception of KCD as a whole (and possible psychosomatic effects) is not expected to change compared to the LTO situation (negligible effect).

3.8 Human - Mobility

3.8.1 Baseline situation

The transport associated with the day-to-day operation of the nuclear power plant is mainly by road. Traffic mainly consists of the vehicles of staff and subcontractors to and from the site. No bus line stops at the Doel power plant. In addition, there are the transports for the supply and maintenance of the installations. KCD also has a quay along the Scheldt, to supply heavy equipment. This quay is used rather sporadically.

The (heavy) traffic to and from the nuclear power plant passes through the Waasland harbour, more specifically around the Deurganckdok, with a connection to the R2. These roads do not cross residential areas. On this main route there are of course a number of other routes, where traffic finds its way through the polders, possibly via Kieldrecht and via the N451 directly to the connection with the N49 expressway Antwerpen - Knokke. From the R2, there is a connection to the A12, the E34, N70, the E17 or the E19.

KCD has a car park with approx. 1,500 parking spaces where staff and contractor vehicles can be parked. On average, there are some 1,700 people present on the site (during the day) and this results in some 1,300 vehicles (cars, trucks, vans, etc.).

The transport of people to and from the site takes place during peak periods, while deliveries by truck can be expected to take place throughout the day. There is no saturation of the local road network to and from KCD. However, heavy traffic in the morning and evening rush hour is possible.

No traffic counts were carried out during the baseline situation. The exact traffic intensities at the intersections are therefore not known.

3.8.2 Impact assessment

The traffic volumes caused by the transport of KCD on the access road to KCD is significant at peak times and negligible beyond.

The work that has taken place in the context of the adjustments for LTO and during the operational phase of KCD in the future situation will lead to a slight increase in the number of transports, because of the construction site traffic and the additional number of employees. Shipments for the supply of construction materials, waste materials and materials to be reused mainly took place outside peak hours. The number of employees will increase slightly with the lifetime extension of Doel 1 and 2, by about 11%. Taking into account a saturation level (off-peak), the effect on traffic handling can be assessed as slightly negative, at most.

During the POP, there will be a gradual decrease in staff, together with a limited increase in material transports. The knock-on effect on traffic flows is assessed as negligible.

In the Zero alternative, a reduction in the workforce would be expected from 2015 onwards, which would have a negligible impact on traffic flows. In the LTO situation, this decline will only occur after 2025.

On the basis of the impact assessment, no mitigating measures are considered necessary. However, some recommendations are proposed:

- Further focus on sustainable modes such as cycling. This can be further expanded by constructing sufficiently comfortable bicycle sheds (covered). Initiatives regarding company bicycles, bicycle allowances, shower facilities and bicycle sharing can also contribute to making travel to and from work more sustainable.
- Focus on carpooling. This has a positive impact on traffic generation and parking needs. By encouraging carpooling within the company (e.g. reserved car-pool parking spaces, car-pool fee, car-pooling system) both among permanent employees and contractors, the nuclear power plant can reduce the traffic intensities produced and make them more sustainable.

No cumulative effects with the complex project "Realisation of additional container handling capacity in the Antwerp port area" are expected. Given the nature and size of the project, it can be assumed that the project will not yet be (fully) completed by 2025. When the Second Tidal Dock and the "Three Docks" logistics area were to be completed during the Post Operational Phase (period 2025-2029), a new access to the study area towards the R2 should be envisaged. Measures will have to be taken in the complex project to guarantee traffic flows.

There are no other projects in the area with cumulative effects.

There are no cross-border effects for the mobility section.

3.9 Waste

3.9.1 Baseline situation

Non-radioactive waste exists in solid, gaseous and liquid forms. Solid waste includes filters, construction waste, computer waste, lamps, paper and household waste. Liquid wastes include waste oils, degreasers, chemicals and sludges from septic tanks. Some wastes may be residual refrigerant waste gases.

Solid and gaseous waste is recycled externally as much as possible, liquid waste is purified. Only if this is not possible, incineration, dumping and discharge are possible. This is done by external approved waste processing companies. The companies authorised to pick up the waste and, subsequently, to process the waste are responsible for the consequences of their activities. The environmental permit for these waste pick-up and processing companies contains preconditions to limit environmental nuisance caused by the removal and recovery of waste.

KCD collects all waste separately. Various collection points are available for this purpose. KCD keeps track of how much waste is disposed of by whom and where it is processed. These accounts meet the legal requirements.

Despite the large total volume of waste, the amount of residual waste (fraction remaining after sorting) is only about 5% of the total weight, due to all kinds of efforts. In 2006, a peak of more than 1,000 m³ of residual waste was recorded. After that time, the amount of residual waste decreased. Every year, the optimisation of KCD's waste policy is included in the environmental objectives in the form of a number of concrete measures (prevention, sorting and recycling). In the following year, the extent to which the measures have been effectively implemented will be assessed. This explains the decreasing trend in the amount of residual waste. In 2014, the total volume of classic waste was 4,830 tonnes, of which 193 tonnes was residual waste.

3.9.2 Impact assessment

The work carried out as part of the LTO adjustments generated a certain amount of waste. No figures are available for waste generated as a result of the LTO. After the implementation of the LTO measures, waste production did not differ significantly from the initial situation (4,830 tonnes of conventional waste). However, the POP will again generate additional waste streams. In addition, waste is also generated during normal operation of the nuclear power plant. However, KCD makes every effort to reduce the impact of non-radioactive waste on the environment. The waste is selectively collected, sorted and disposed of according to specific properties.

KCD has an environmental management system for its waste streams in accordance with the international standard ISO14001 and the European EMAS Regulation. Also the regulations laid down in VLAREMA and VLAREBO are followed. No additional mitigating measures or recommendations are considered necessary.

A POP in 2015 (= Zero alternative) would have produced less total waste than an LTO of Doel 1 and 2 to 2025. This is the waste resulting from the construction and excavation works and waste resulting from the normal operation of Doel 1 and 2.

There are no cross-border or cumulative effects for the Waste section.

3.10 Accident situations

The maximum impact distances of a non-radiological incident at KCD-1 and KCD-2 do not extend beyond the site boundaries. The probability of a potential environmental impact does not change significantly as a result of LTO works or as a result of the longer operation of KCD-1 and KCD-2. No significant negative impact is expected on the IHDs of surrounding SPA areas.

4 Effects of the radiological aspects

The EIR lists the environmental impacts of the Project and of the alternative, compared to the baseline situation. To this end, the following radiological environmental aspects were examined:

- Direct radiation at the site boundary
- Radiation exposure of employees
- Radioactive gaseous discharges
- Radioactive liquid discharges
- Radioactive waste
- Spent fuel elements
- Total effective follow-on dose[2] during normal operation
- Accident situations

To identify the environmental impacts, the following topics are described for each aspect:

Topic	It describes
Methodology	What method is used to measure an environmental impact and how the measurement takes place
Baseline situation	The condition of the environment prior to implementation of the Project or the Zero Alternative
Environmental Impact of the Project	The Project implementation's effect on the environment
Environmental Impact of the Zero Alternative	What effect implementing the Zero alternative will have on the environment
Cumulative effects (where relevant)	Cumulative environmental impacts, over the entire duration of the Project
Cross-border effects	Whether any environmental impacts beyond the national border can be expected, and if so, their size
Monitoring	In what way is the relevant environmental impact monitored by authorized bodies?
Mitigating measures	Whether measures are required to reduce environmental impacts, and if so what they are
Knowledge gaps	Whether information is still missing to adequately assess an environmental impact

Radiological aspects are explained in more detail below. For all environmental aspects, as a result of the Project, potential impacts originating from KCD-1 and KCD-2 will occur for 10 more years.

[2] The follow-on dose is the accumulated dose over the entire time a radioactive substance will be present in the body.

4.1 Normal operation

4.1.1 Direct radiation at the site boundary

Virtually all of the radioactivity at the KCD site is in the reactor cores and spent fuel elements, radioactive waste, and facilities where radioactive material is processed and temporarily stored. Both the reactor buildings, the FCB and WAB building are designed to absorb virtually all emitted ionizing radiation. Nevertheless, the various systems - as well as work on the KCD site - can lead to increased doses. To assess its impact on the population, the dose at the site boundary of KCD is considered. This point was chosen because it is the point closest to KCD where any member of the population could be.

Direct radiation at the site boundary is a component of the total effective follow-on dose to which a member of the public may be exposed as a result of the operation of KCD. The effects of the Project on the effective follow-on dose dose to a member of the population is described in § 4.1.7.

Methodology
The dose is measured at the site boundary by 24 dosimeters. These dosimeters (like all other types of dosimeters) cannot distinguish between natural background radiation (including cosmic rays and radiation from building materials) and radiation from KCD. For the current assessment, a background radiation of 0.70 mSv per year is assumed[3], which corresponds to the lowest established average background radiation in the north of Belgium.

Baseline situation
The average dose at the site boundary of KCD is around the background dose in the baseline situation. Measurement points at the site boundary at the level of the WAB and FCB show a slightly increased average dose. Relative to the background radiation (0.70 mSv per year), this is an increase of 0.20 mSv per year.

The maximum increase that may occur as a result of the operation of KCD is set by law at 1 mSv per year for a member of the population. It can therefore be stated that in the baseline situation, the highest measured dose (above background radiation) is still well below the permitted limit.

Operational phase of the Project between 2015 and 2018
During Project implementation between 2015-2018, a slightly elevated dose was measured at the site boundary compared to the baseline situation prior to the Project (2012-2014). As in the baseline situation, the highest dose was measured at the level of the WAB and FCB buildings. It is somewhat higher than the baseline situation and still falls well within the legal total effective dose limit for a member of the population. Although no clear source can be identified, the increase is probably due increased amount of stored spent fuel elements in the FCB at this stage.

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[3] The milisievert (symbol mSv) is a unit for the equivalent dose of ionizing radiation to which a human being is exposed in a given period of time.

Operational phase in the future situation (period 2019 - 2025)

During the operational phase (2019-2025), the maximum dose expected at the site boundary is similar to the dose during the Project phase between 2015-2018. Based on this, it can be concluded that the Project will not have a significant impact on the environment with respect to direct radiation in this phase either.

Cumulative effects

The cumulative dose due to the operation of KCD with the implementation of the Project, which a person would incur from direct radiation if they were continuously at the site boundary, is 2.9 mSv (11 years at 0.27 mSv per year). To illustrate, this cumulative dose is well below the average background dose of Belgium (43.8 mSv).

Zero alternative

If no LTO were to take place, KCD-1 and KCD-2 will be shut down and the POP will be started. From then on, the operation of KCD-1 and KCD-2 will have no direct impact on the radiation level at the site boundary. During the POP period of KCD-1 and KCD-2, direct radiation due to KCD-1 and KCD-2 will continue to contribute to the dose at the site boundary. As described earlier, the dose contribution at the site boundary is primarily determined by direct radiation from the FCB.

In case of the Zero alternative, it can only be stated that the observed increase in dose near the FCB (0.07 mSv per year), will not occur because the Project is not implemented in the Zero alternative.

Cross-border effects

Virtually all dose originating from direct radiation from KCD consists of gamma photons whose dose rate decreases quadratically as distance increases. The closest land border is that of the Netherlands. The dose at the site boundary relative to background radiation (0.7 mSv) was 0.20 mSv in the baseline situation. At the Dutch border, this results in a dose rate of 0.000078 mSv per year. In accordance with the Dutch Basic Safety Standards Decree, the permissible limit is 0.1 mSv per year due to direct radiation, liquid and gaseous radioactive discharges. Therefore, the dose rate is extremely low. As the dose rate will continue to decrease as the distance from the KCD increases, the operation of KCD will also have no impact on more distant countries (including France, Germany, Luxembourg and the United Kingdom). Cross-border effects due to direct radiation can thus be excluded.

Monitoring

FANC manages a national network (TELERAD network) with over 250 measuring stations on the Belgian territory. It continuously measures radioactivity in the air and in water. Around KCD a relatively large number of measuring stations are set up which continuously measure the dose. Any deviations in the dose will immediately trigger an alarm once a warning threshold is exceeded.

Mitigating measures

Based on available data, direct radiation at the KCD site boundary does not increase significantly and no mitigation measures are required.

Knowledge gaps

It should be noted that the measured values of the site boundary dose are in the order of the background radiation. It should also be noted that there is no unambiguous explanation for the slightly higher values of some measurement points relative to the other measurement points around the site. These gaps in knowledge do not interfere with decision making because out of conservatism, the highest readings at the site boundary were assumed to be from KCD-1 and/or KCD-2.

4.1.2 Radiation exposure of employees

About 2,000 people work at the Doel nuclear power plant every day, both in-house and external employees. A large portion of these, the non-professionally exposed employees, are not exposed to ionizing radiation (other than background radiation). However, some of the employees (the employees exposed as part of their profession) may be exposed to ionizing radiation during their work, especially when working in the radiologically controlled areas.

Methodology
The radiation exposure for occupationally exposed workers is continuously monitored, particularly by personal dosimeters. The dose sustained is tested for each employee against KCD's internal limit (10 mSv per year). This internal limit is half the legal limit of 20 mSv per 12 consecutive sliding months.

To determine the radiation exposure for non-professionally exposed employees at the site, available dose data from so-called "blank monitors" are used. These are set up in representative locations of various buildings outside the radiologically controlled area and are read out regularly. For non-professionally exposed workers, the legal limit is 1 mSv per year, equal to the total dose limit for a member of the population.

Baseline situation
In the baseline situation (2012-2014), the average effective dose of all occupationally exposed workers was about a factor of six lower than the average effective dose for workers in the nuclear work area as published by UNSCEA*(United Nations Scientific Committee on the Effects of Atomic Radiation*) in 2000. The average effective dose of all employees who are occupationally exposed at KCD is well below the KCD internal limit of 10 mSv per year and therefore also well below the legal limit for occupationally exposed persons. For the non-professionally exposed employees, based on the so-called "blind monitors", the average exposure is negligible.

Operational phase of the Project between 2015 and 2018
Performing works during the Project's operational phase between 2015-2018 results in a slight increase in the collective dose (the dose of all employees combined) for occupationally exposed employees compared to the baseline situation. However, as more employees are deployed to implement the LTO measures, the average effective dose per employee is still well below the KCD internal limit of 10 mSv per year. This concludes that this phase has no significant negative impact on occupationally exposed employees.

For non-professionally exposed employees, as in the previous section, so-called blind monitors can be used. Based on the blind monitors, it can be concluded that the average exposure for these employees is negligible. From this, it can be concluded that the operational phase of the Project between 2015 and 2018 has no impact on the dose for non-occupationally exposed employees.

Operational phase in the future situation (period 2019 - 2025)
The dose during the operational phase in the Future Situation (2019-2025) is similar to that during the baseline situation.

Zero alternative
Under the Zero Alternative, both KCD-1 and KCD-2 will be permanently discontinued. In that case, employees will no longer be exposed to ionizing radiation as a result of the operation of KCD-1 and KCD-2. The annual collective dose for occupationally exposed employees in this case is formed by the operation of only KCD-3 and KCD-4 and the POP work. Because of the radiological shielding of KCD-1 and KCD-2, discontinuing these units will have little effect on the annual dose of non-professionally exposed employees. Electrabel expects, based on POP work that has taken place at German nuclear power plants over the last 10 years, that the exposure of occupationally exposed workers is significantly lower than during work during operation.

Cross-border effects
All employees, regardless of where they live, are subject to Belgian law. So no cross-border effects are applicable.

Monitoring
By law, the minimum monitoring that must be done by the employer is regulated. This is supervised by the FANC. Personal dosimetry is performed by an independent institute recognized by FANC. Blind monitors also monitor the exposure of non-exposed personnel.

Mitigating measures
The infrastructure of KCD-1 and KCD-2 to protect against radiation exposure is such that the applicable criteria are amply met. Therefore, no additional mitigation measures are required.

Knowledge gaps
The available knowledge is sufficient to determine the effects of radiation exposure resulting from implementation of the Project. There are no gaps in knowledge that impede proper impact assessment.

4.1.3 Radioactive gaseous discharges

Radioactive gases are produced as a result of the operation of KCD. These are captured within the nuclear units and stored long enough for the short-lived radionuclides to decay. This greatly reduces the radioactivity of the gases. After decay, the gases are filtered and discharged through the ventilation shaft. Prior to discharge, the activity concentration is determined. If the activity exceeds the established activity limit, no discharge will occur. Finally, the activity values measured at the time of discharge are recorded so that compliance with applicable licensed limits can be demonstrated.

The radioactive gaseous discharges cause a portion of the total effective follow-on dose to which a member of the public may be maximally exposed as a result of the operation of KCD. This total effective follow-on dose is described in § 4.1.7.

Methodology
A model is used to determine how the gases disperse into the atmosphere after discharge. This model is based the *United States Nuclear Regulatory Commission*'s calculation methodology. The calculation results are then used to calculate the effective follow-on dose according to an internationally recognized methodology; which was adapted to the Belgian context by FANC. In addition, to detect abnormal radioactive contamination of the food chain, moss, grass and soil samples are taken and analyzed annually.

Baseline situation
The discharge in the baseline situation was determined based on the annually reported activity which was discharged to the atmosphere in 2012 through 2014. Most of the discharged activity comes from noble gases and - to a lesser extent - from tritium. All discharged activities are well below the licensed discharge limits. The 2012-2014 data do show a slight spread between years. This is caused by various factors that fluctuate from year to year such as production time and operations.

Operational phase of the Project between 2015 and 2018
In the period 2015-2018, the LTO measures will be implemented during overhauls and the units will be operated similar to the baseline situation. Although many activities are performed in addition to regular operations, the radioactive gaseous discharges during the Project's operating phase between 2015 and 2018 are similar to the baseline situation. As a result, the operational phase of the Project between 2015 and 2018 has a negligible environmental impact.

Operational phase in the future situation (period 2019 - 2025)
During the period 2019-2025, KCD-1 and KCD-2 will continue to be operated. Because the operating processes have not changed, the total discharged gaseous activity is not expected to change from the baseline situation during the 2019-2025 period. As a result, the operating phase of the Project between 2019 and 2025 of the Project also has a negligible impact on the environment.

Cumulative effects
The highest possible cumulative dose at the KCD site boundary due to radioactive gaseous discharges during the Project is 0.044 mSv. This is comparable to the dose incurred during one transatlantic flight (0.040 to 0.050 mSv). The discharged activity and the effective follow-on dose due to radioactive gaseous discharges during regular operation are not expected to deviate from the baseline situation after the implementation of the LTO measures.

Zero alternative
If no life extension takes place, both KCD-1 and KCD-2 will be discontinued. Therefore, under the Zero Alternative, no discharge of activity to the atmosphere will occur as a result of the operation of KCD-1 and KCD-2, only by KCD-3 and KCD-4. The effective follow-on dose due to the operation of KCD, without KCD-1 and KCD-2, is compared to the baseline situation of the entire site from which the dose contribution due to KCD-1 and KCD-2 is subtracted, leaving only the routine discharges from KCD-3 and KCD-4.

On the basis of the POP work that has taken place at German nuclear power plants over the last 10 years, Electrabel expects considerably lower gaseous discharge volumes than during works occurring during operation. As a result, the ultimate difference in radioactive gaseous discharges between the Zero Alternative, the Baseline Situation, and the Project is negligible.

Cross-border effects

The radioactive gaseous discharges are discharged into the atmosphere and carried and diluted by the wind. Depending on the wind, the discharged gases reach the border with one or more of the surrounding countries. Of all the national borders, the Dutch border is located closest to KCD; approximately 3 km. Based on the licensed discharges in the baseline situation, the effective follow-on dose at the Dutch border was calculated. Those calculations show that the effective follow-on dose is well below the more stringent Dutch legal limit (0.1 mSv/year) of the total effective dose for a member of the Dutch population.

For the other surrounding countries (France, Germany, Luxembourg and the United Kingdom), the effective follow-on dose at the respective country border was also calculated. The calculations show that the effective follow-on dose at the borders of France, Germany, Luxembourg and the United Kingdom due to KCD is significantly lower than the follow-on dose at the Dutch border. This also makes the total effective dose well below the permissible limit for a member of the Dutch population.

Monitoring

Radiological monitoring on the Belgian territory is carried out periodically by FANC. Measurements of ambient air, rain water, soil and milk, among others, are taken in the vicinity of KCD. In this way, it is evaluated whether the quality of the environment remains radiologically adequate.

Mitigating measures

Based on the available data, the radioactive gaseous discharges from KCD-1 and KCD-2 have no significant impact on the environment and no mitigation measures are required.

Knowledge gaps

Exact data on the origin of discharges from the WAB are not always available. For the current assessment, an assumption was made as to what portion of the discharged activity to the atmospheric from the WAB is attributed to KCD-1 and KCD-2. The available knowledge is therefore sufficient to determine the effects of the gaseous radioactive discharges of this intention.

4.1.4 Radioactive liquid discharges

KCD discharges a controlled amount of radioactive wastewater into the Scheldt, always only after it has been determined that the discharge complies with the licence limits. The discharges consist mainly of process water collected within the plant (e.g., during work on systems with primary cooling water, analytical samples, or quench water from the radiologically controlled area). Wastewater from all units is collected in the WAB, where as many radionuclides as possible are removed from the water.

The radioactive liquid discharges cause a portion of the total effective follow-on dose to which a member of the public may be maximally exposed as a result of the operation of KCD. This total effective follow-up dose is described in § 4.1.7.

Methodology
The activity values measured at the time of discharge are recorded to demonstrate compliance with applicable licensed limits. Based on the internationally recognized calculation method of the *United States Nuclear Regulatory Commission*, which was adapted to the Belgian context by FANC, the effective follow-on dose is calculated. In addition, water samples are taken and examined annually upstream and downstream of the discharge point, at various distances from KCD. The results of these campaigns provide an understanding of the actual absorption of radionuclides into the environment.

Baseline situation
During the baseline situation, the nuclear units were operated and work was carried out during overhauls. The discharged activity during the Baseline Situation (2012-2014) consists primarily of tritium and is very well below the licensed discharge limits for all of KCD.

Operational phase of the Project between 2015 and 2018
In terms of its nature, this phase of the Project is similar to the baseline situation. This is reflected in the discharged activities during the period 2015-2018. The data for this period does show a slight spread between years. The fluctuations can be caused by various factors, such as the nature of the work and total unit production time. As a result, the operational phase of the Project between 2015 and 2018 has a negligible environmental impact.

Operational phase in the future situation (period 2019 - 2025)
After implementation of the LTO measures, the units (KCD-1 and KCD-2) will continue to be operated during the operational phase in the future situation (2019-2025). Also during this phase, work will take place during overhauls and activity will be discharged into the Scheldt. Therefore, there will also be no difference between the operation during the baseline situation (2012-2014) and the operational phase in the future situation and the discharged activity is expected to be similar to the discharged activity during the baseline situation.

Cumulative effects
The highest possible cumulative dose at the site boundary of KCD is 0.003 mSv as a result of continued operation of KCD-1 and KCD-2. This cumulative dose due to liquid radioactive discharges is very small and will not result in significant measurable effects.

Zero alternative
If the Project does not take place, both KCD-1 and KCD-2 will be permanently discontinued, after which only routine discharges from KCD-3 and KCD-4 will occur. The effective follow-on dose due to the operation of KCD, without KCD-1 and KCD-2, is compared to the baseline situation of the entire site from which the dose contribution due to KCD-1 and KCD-2 is subtracted, leaving only the routine discharges from KCD-3 and KCD-4.

After the decommissioning of KCD-1 and KCD-2, the POP begins, preparing these units for decommissioning. During the emptying of primary circuits and the cleaning of various systems, various wastewater streams will be generated and collected for processing in the WAB. In the WAB, the existing activity is removed from the water as much as possible. On the basis of the POP work that has taken place at German nuclear power plants over the last 10 years, Electrabel expects considerably lower liquid radioactive discharge volumes than during works occurring during operation. As a result, the ultimate difference in radioactive liquid discharges between the Zero Alternative, the baseline situation, and the Project is negligible.

Cross-border effects
The radioactive liquid discharges into the Scheldt, which flows into the North Sea via Dutch territory. Based on the licensed radioactive liquid discharges of all of KCD, the effective follow-on dose was calculated at the Dutch border. Those calculations show that the effective follow-on dose is well below the more stringent Dutch legal limit (0.1 mSv/year) of the total effective dose for a member of the Dutch population.

For the other surrounding countries (France, Germany, Luxembourg and the United Kingdom), doses due to radioactive liquid discharges into the Scheldt are more difficult to assess than for atmospheric discharges. This is partly because the distribution in rivers and seas is complex. However, due to the large distance of KCD from the relevant boundary, doses due to radioactive liquid discharges can be considered negligible.

Monitoring
Radiological monitoring in Belgium is carried out by FANC. Measurements are taken upstream and downstream of KCD, such as of surface water, sediment, algae, and fish. This makes it possible to continuously evaluate and monitor the impact of radioactivity on the environment.

Mitigating measures
The facilities of KCD-1 and KCD-2 serving the radioactive liquid discharges are such that the applicable criteria are amply met. Therefore, no additional mitigation measures are required.

Knowledge gaps
Exact data on the origin of discharges from the WAB are not always available. Therefore, for the current assessment, an assumption was made as to what proportion of water is allocated to KCD-1 and KCD-2. The available knowledge is sufficient to determine the effects of the liquid radioactive discharges upon implementation of the Project.

4.1.5 Radioactive waste

Many different waste streams are generated during operation, most of which are non-radioactive and disposed of as non-radioactive waste.

A small portion of the waste streams contain significant amounts of radionuclides and should therefore be disposed of as radioactive waste. This includes low and medium level radioactive waste. Examples of low-level radioactive waste include contaminated personal protective equipment (including gloves), cleaning materials, filters, and replaced parts (including pipe sections). Examples of intermediate-level radioactive waste are resins and when a nuclear power plant is decommissioned some components of the reactor.

In addition to low and medium level waste, high level waste also exists. This is characterized by large amounts of alpha, beta, and/or gamma-emitting nuclides. No high-level radioactive waste is generated during the operation of KCD. Spent fuel elements are highly radioactive, but because no decision has yet been taken in Belgium as to whether spent fuel elements might be reprocessed at a later date (which will reduce the total volume of highly radioactive waste), spent fuel elements are not considered waste for the time being (see § 4.1.6).

The main radiological environmental aspect of radioactive waste is ionizing radiation. As long as the waste is at the KCD site, it contributes to the dose at the site boundary. Therefore, this is part of direct radiation at the site boundary and is factored in.

Methodology
In addition to preventing the generation of waste, reduction of the volume of radioactive waste is seen as an important (and legally required) measure to minimize the quantities of waste. At KCD, all solid radioactive waste is collected in the WAB. In the WAB, mechanical and/or chemical processes reduce the volume as much as possible. After which it is packaged and, where possible, conditioned in a concrete mix before being transported to Belgoprocess. The amount of radioactive waste is typically expressed in volumes. The volumes disposed of are reported in KCD's annual environmental statements.

Baseline situation
In the baseline situation, most waste is generated as a result of operations during regular overhauls. Because the overhauls vary in duration and type of work, the annual volume varies from year to year. The average waste quantities disposed of per year over the period 2012-2014 were used as the starting point for the baseline situation.

Operational phase of the Project between 2015 and 2018
The average waste quantities disposed of per year over the period 2015-2018 are slightly lower than those in the baseline situation. However, it should be taken into account that it is not all the waste generated in this phase that has already been processed in the WAB and then disposed of. It is anticipated that this will occur during the course of the operational phase in the future situation.

Operational phase in the future situation (period 2019 - 2025)
It is expected that the total amount of radioactive waste in the operating phase in the future situation will not differ significantly from the baseline situation because the baseline situation and operating phase are similar in the future situation. However, some fluctuation per year can be expected in waste volumes disposed of, also considering the processing of waste as a result of the LTO measures.

Cumulative effects
The cumulative amount of radioactive waste resulting from the LTO project for the period 2015-2025 is 363m^3 (11 years 32.9 m^3 per year).

Zero alternative
In the case of the Zero Alternative, KCD-1 and KCD-2 will be discontinued and the POP will be initiated. Radioactive waste will be generated during the POP. Therefore, the waste from the POP activities is also treated in the WAB where possible. It is expected that the quantities of radioactive waste over the entire period of the POP will be lower on an annual basis than the quantities during operation. Therefore, from 2015 onwards, there will be no radioactive waste resulting from the operation of KCD-1 and KCD-2, but there will be radioactive waste resulting from activities related to POP.

Cross-border effects
All waste generated will be processed and stored on Belgian territory until a final solution is found. NIRAS (National Institution for Radioactive Waste and Enriched Fissile Materials) manages the radioactive waste isolated from the environment until the activity of the waste is reduced by decay to below the exemption values applicable in Belgium. As a result, no cross-border impacts are anticipated.

Monitoring
The waste streams within KCD are monitored and recorded by Electrabel. The volumes of low- and medium-level radioactive waste disposed of from KCD are monitored by NIRAS and Belgoprocess, under the supervision of FANC.

Mitigating measures
To minimize the total volume of low and medium level radioactive waste, solid waste is processed in the WAB (pressed and shredded) and solid waste is incinerated (at Belgoprocess). Using these technologies leads to a strong volume reduction of waste.

Knowledge gaps
The available knowledge is sufficient to determine the radioactive waste impacts of this plan. Despite the fact that the exact origin of the disposed waste from the water and waste treatment building is not always unambiguously assignable to a particular unit. Total waste generation also depends on many factors and is therefore very difficult to predict.

4.1.6 Spent fuel elements

A cycle of KCD-1 and KCD-2 lasts an average of 12 months, after which the fuel elements in the core are reclassified to compensate for the decrease in fuel in an element. During this process, on average, a quarter of the nuclear fuel elements are replaced with new elements.

The main radiological environmental aspect of spent fuel elements is the ionizing radiation emitted by the elements during transport to and storage at the FCB. Therefore, this is part of the direct radiation at the site boundary and employee radiation exposure and is included in these two aspects.

Methodology
The number of spent fuel elements disposed of was determined based on Electrabel's published environmental statements. In it, the number of fuel elements per year is published; therefore, the methodology applies an annual approach.

Pending the decision of the Belgian government regarding the reprocessing of spent fuel elements, all spent fuel elements should be stored at the site. However, the result is that with each year of operation, the number of spent fuel elements stored at the site increases.

Baseline situation
The number of fuel elements replaced at the end of a cycle is variable. This is because it depends, for example, on energy production and the duration of the cycle. The starting point for the baseline situation

is the multi-year average number of spent fuel elements disposed of over the years 2012-2014. For both KCD-1 and KCD-2, these are 32 pieces per year.

Operational phase of the Project between 2015 and 2018

During the operational phase of the Project between 2015 and 2018, KCD-1 and KCD-2 will be operated in a similar manner as during the baseline situation. Therefore, the production rate of spent fuel elements in the operation phase of the Project between 2015 and 2018 is the same as in the baseline situation.

Operational phase in the future situation (period 2019 - 2025)

The rate of consumption of fuel elements in the operational phase (2019-2025) will be similar to that of the baseline situation. Therefore, its environmental impact during the operational phase of the Project between 2015 and 2018 is also determined by the number of additional spent fuel elements stored and disposed of at the FCB. This results in the annual increase during the operating phase in the future situation (period 2019 - 2025) being equal to that in the baseline situation.

Cumulative effects

Based on the multi-year average fuel consumption, KCD-1 and KCD-2 will use approximately 664 additional fuel elements during the Project.

Zero alternative

Within the Zero Alternative, operation of KCD-1 and KCD-2 stops, the POP phase starts, and the production rate of spent fuel elements decreases to zero, reducing its impact on the environment.

At the beginning of the POP, all fuel elements present in both reactors are transferred to the fuel basin for further cooling. During POP, all fuel elements - when sufficiently cooled - are transferred to the FCB. At the end of the POP period, no fuel elements are present at KCD-1 and KCD-2.

Cross-border effects

Since the Belgian government has yet to take a decision regarding further processing of spent fuel elements, they are not considered radioactive waste for the time being. Possible transportation of these elements to other countries for reprocessing, resulting in possible environmental impacts, are therefore not considered in this EIR.

Monitoring

The number of spent fuel elements is reported annually. Additional monitoring compared to the current situation is therefore not required.

Mitigating measures

The infrastructure of KCD-1, KCD-2, and FCB for spent fuel elements is adequately equipped to amply meet the applicable criteria. Therefore, no additional mitigation measures are required.

Knowledge gaps

Currently, the Belgian government has not yet made a decision regarding the final destination of spent fuel elements. Therefore, the long-term effects beyond the site boundary of KCD cannot be determined at the time of preparing this environmental impact assessment.

4.1.7 Total effective follow-on dose

The total effective follow-on dose is the dose to which a member of the population may be maximally exposed as a result of the operation of KCD. This total effective follow-on dose is the sum of a number of radiological aspects described separately above, namely:

- Direct radiation (§ 3.2.1),
- Effective follow-on dose resulting from radioactive gaseous discharges (§ 3.2.3) and
- Effective follow-on dose resulting from radioactive liquid discharges (§ 3.2.4)

Methodology
The maximum dose that a member of the population can receive is calculated for a so-called *critical individual*. This is a person who may incur the maximum dose based on very conservative assumptions. It is assumed, for example, that the person will be at the site boundary where the highest dose rate is measured throughout the year, while at the same time the person will also be at the site with the highest airborne activity and also at the site with the highest activity deposition.

The total effective follow-on dose is tested against the legal limit of 1 mSv per year for a member of the population. As described earlier, this limit of 1 mSv applies to the dose resulting from the operation of a nuclear facility and is therefore in addition to the natural background radiation.

Baseline situation
The total effective follow-on dose was determined for the years 2012 through 2014. The total average effective follow-on dose to the critical individual resulting from the operation of all of KCD during the baseline situation is 0.23 mSv per year.

Operational phase of the Project between 2015 and 2018
The total effective follow-on dose was determined for the years 2015 through 2018. The total average follow-on dose to a critical individual due to the operation of KCD during the construction phase of the baseline situation is 0.30 mSv per year.

The change from the baseline situation is mainly caused by the larger proportion of direct radiation at the site boundary, which is probably caused by the larger number of spent fuel elements stored in the FCB.

Operational phase in the future situation (period 2019 - 2025)
After the operational phase of the Project between 2015 and 2018, the units will be operated in a further operational phase in future situation (period 2019 - 2025) as during the baseline situation. Therefore, it is likely that the dose during the operation phase will not be significantly different from the operational phase of the Project between 2015 and 2018.

Cumulative effects
The maximum cumulative dose due to this Project is expected to be 3.3 mSv. Because the various dose calculations use extremely conservative methods, the calculated cumulative dose resulting from this

Project is a strong overestimate of a real dose. Nevertheless, the calculated cumulative dose is well below the induced cumulative dose limit[4] (11 years × 1 mSv = 11 mSv) and no significant effects are expected.

Zero alternative
Under the Zero Alternative, KCD-1 and KCD-2 will be discontinued in 2015 and the POP will be started. The difference between the Project and the Zero alternative is determined by the increase in direct radiation dose at the site boundary, which is likely caused by the greater number of spent fuel elements stored at the FCB. On the other hand, the shutdown of KCD-1 and KCD-2 will stop the gaseous and liquid radioactive discharges resulting from the operation of these units. As a result, the expected total effective follow-on dose of KCD due to direct radiation, liquid and gaseous radioactive discharges, and waste releases will be slightly lower under the Zero alternative than under the Project.

In general, it can be said that the annual radiological impact of POP is smaller than that of operating the unit in question.

Cross-border effects
Theeffective follow-on dose due to the operation of KCD for the Dutch population was determined to be 0.027 mSv per year. This is well below the Dutch total effective dose limit of 0.1 mSv per year for a member of the population.

For the other surrounding countries (France, Germany, Luxembourg and the United Kingdom), the effective follow-on dose due to atmospheric and liquid radioactive discharges at the respective country border was also calculated. The calculations show that the effective follow-on dose at the borders of France, Germany, Luxembourg and the United Kingdom due to KCD is significantly lower than the follow-on dose at the Dutch border and therefore also far below the permissible limit of the total effective dose for a member of the population as used by IAEA *(International Atomic Energy Agency*).

Monitoring
The monitoring of the individual radiological aspects from which the total effective full dose was calculated is described in the relevant paragraphs (§ 4.1.1, § 4.1.3 and § 4.1.4).

Mitigating measures
The mitigating measures for the individual radiological aspects from which the total effective full dose was calculated is described in the relevant paragraphs (§ 4.1.1, § 4.1.3 and § 4.1.4).

Knowledge gaps
The existing uncertainties in knowledge regarding the total effective dose are described below in § 4.1.1, § 4.1.3 and § 4.1.4. However, the available knowledge is sufficient to determine the effects of the total dose of this intention. The gaps in knowledge therefore do not affect the assessment and therefore do not hinder the decision making.

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[4] This is not a legal limit. The legal limit is 1 mSv per year.

4.2 Accident situations

One of the main topics of the Project, in addition to managing obsolescence, is to increase the nuclear safety of the KCD-1 and KCD-2. As a result of the modifications made as part of the Project, a positive impact in terms of accident events is expected during the continued operation of KCD-1 and KCD-2. From an environmental perspective, this means that the likelihood of an accident situation involving a radioactive discharge is reduced, and thus the likelihood of a potential environmental impact is reduced.

Methodology
The maximum allowable risks are included in the KCD safety report. As a result of the planned changes to the installation, it must be ensured through analyses that, after implementation, nuclear safety is at least at the same safety level as before implementation. Any change in the plant is coordinated with FANC. After obtaining approval from FANC, the relevant change may be implemented.

Baseline situation
At the time of the baseline situation (2012-2014), various obsolescence control and safety enhancement measures were identified that could be implemented during the construction phase of the Project, such as:

- Installing a system for filtered pressure relief from the containment,
- Improving automatic fire suppression,
- Implementing the physical separation of the electrical systems,
- Tightening procedures for testing.

All measures combined reduce the likelihood and/or consequences of accident situations.

Operational phase of the Project between 2015 and 2018
During the operational phase of the Project (2015-2018), the Integrated Action Plan and the works to be carried out under the Project, as described in the Long Term Synthesis Report - Doel 1and Doel 2 from 2015, have been implemented. It is assumed that the measures will not be completed until the end of the 2015-2018 period so that no credit can be taken for these measures in this period.

Operational phase in the future situation (period 2019 - 2025)
After implementation of all measures, nuclear safety for the operational phase of KCD-1 and KCD-2 (2019-2025) is improved compared to the baseline situation. This results in a lower probability of an accident situation involving radioactive discharges during the operational phase than in the baseline situation. As part of the Project, the probabilistic safety study (PSA) was updated, calculating the effective follow-on dose at the site boundary of the KCD site for two reference design-based accidents[5]

[5] Design-based accidents are hypothetical events that could occur at the facility in question and, thanks to the safety systems included in the design, would not result in unacceptable releases of radioactivity to the environment.

and the reference out-of-design base accident[6]. It can be concluded that the effective follow-on dose resulting from the reference accidents remain within the licensed limits for design-based accidents.

Zero alternative
In the zero alternative, KCD-1 and KCD-2 are discontinued. Because a shutdown reactor poses a smaller safety risk than one that is being operated, the likelihood of an accident situation involving a radioactive discharge and possible environmental effects decreases.

The residual risk is formed by the activities that are still being performed during the POP phase. The removal of the decay heat will require the fuel elements to be cooled. This is done primarily using the reactor cooling circuit. The reactors will then be completely emptied, with the fuel assemblies transferred to the fuel pools and then cooled using the cooling circuits of this basin. During POP, an accident resulting from improper handling of fuel elements still remains relevant. Calculations show that the effective follow-on dose if this accident were to occur is well within the licensed limits.

Cross-border effects
Although the probability is very small, the consequences of the largest conceivable design-based accidents will have a strong cross-border effect. Here, the effects for the Netherlands are especially relevant, due to the close location and due to the most common wind direction (southwest). As a result, any released radionuclides will be transported towards Dutch territory. As the project measures reduce the probability and possible consequences of accidents, this reduction will also apply to the Dutch territory.

Analyses have shown the reference design-based accidents meet the licensed limits. These analyses were also carried out for the countries of France, Germany, Luxembourg and the United Kingdom (bordering on Belgium), with the conclusion that the effective dose is reduced by at least a factor of 65 compared to the effective dose at the Dutch border as a result of the reference design-based accidents.

For other country boundaries that are more 1000 km away from KCD-1 and KCD-2 (such as Sweden, Austria, Poland, Czech Republic, Denmark, and Ireland), it was concluded that there is a non-significant radiological impact because of design-based accidents.

In addition to design-based accidents, beyond-design accidents were also considered. As with design-based accidents, it has been determined for the reference beyond-design accident that the radiological consequences at the Dutch border meet the statutory dose reference levels for the purpose of nuclear and radiological emergency plans. Likewise, for the countries of France, Germany, Luxembourg and the United Kingdom (bordering on Belgium), the effective dose is reduced by at least a factor of 55 compared to the effective dose at the Dutch border in case of the reference beyond-design accident. For other country boundaries that are more 1000 km away from KCD-1 and KCD-2 (such as Sweden, Austria, Poland, Czech Republic, Denmark, and Ireland), it was concluded that there is a non-significant radiological impact because of design-based accidents.

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[6] A beyond-design accident is an accident that goes beyond a design-based accident. The probability of a beyond-design accident occurring is still much lower than the probability of a design-based accident. For this reason, the design for the beyond-design accidents considers only how to reduce the residual risk by reasonable means (technical, organizational).

Monitoring
Any change in the plant is coordinated with FANC, where calculations are performed to determine the effect of the modification on nuclear safety. Only after approval of FANC may the relevant change be carried out.

Mitigating measures
Electrabel can and must meet the accident criteria in force in Belgium. To this end, KCD-1 and KCD-2, as well as KCD-3, KCD-4, WAB and the FCB, are equipped with various safety features and have an emergency plan which must be consistent with the national nuclear and radiological emergency plan. No additional mitigation measures under the Project are therefore necessary.

Knowledge gaps
There are no gaps in knowledge that affect the alternatives considered and thus do not impede decision making.

5 Conclusion

5.1 Non-radiological aspects

The impact of the effects will not be significantly different in the LTO situation from the effects in the baseline situation. There are no additional effects of the LTO situation compared to the baseline.

The impact of the operation of KCD on the environment was studied for the period 2015-2018 compared to the situation without operation of KCD. It can be concluded that the impact on the environment for most environmental aspects is negligible to limited compared without KCD operation. This does not apply to the discharge of cooling water. The discharge of the cooling water has a negative to considerably negative impact as a result of the temperature increases. The effect of temperature increase on the aquatic communities in the Lower Scheldt is considered not considerably negative. A frequent operation of the site's sanitary wastewater collection wells into the Scheldt was found to have a negative effect. To the east of the KCD, the 55 dB nuisance contour reaches into the Birds Directive area 'Schorren en polders van de Beneden-Schelde', also designated as the VEN area 'Slikken en schorren langs de Schelde' and as a Ramsar area. Rest disturbance due to the operation of KCD along the reed zones and mudflats on the banks of the Scheldt, near the KCD, is assessed as negative.

5.2 Radiological aspects

The total effective follow-on dose is below the legal limit for effective follow-on dose to the population for both the Zero Alternative and the Project.

In summary, it can be concluded that for both the Project and the Zero alternative, the impact on the environment for most environmental aspects is negligible compared to the baseline situation. There is a minor impact due to the environmental aspects of radioactive waste and spent fuel elements, which is factored into the direct radiation at the site boundary. Under both the Project and the Zero Alternative, the likelihood of an accident situation involving radioactive discharges is lower than under the Baseline situation.

As a result of the operation of KCD-1 and KCD-2, fuel elements are consumed and radioactive waste is generated. Under the Zero Alternative, operation of KCD-1 and KCD-2 ceases and only radioactive waste is generated by operations for the POP.

The radiological impact due to the POP will be smaller than during the operation of the unit in question.