3 PROJECT DESCRIPTION

3.1 Introduction

Eskom proposes to construct a Nuclear Power Station, referred to as Nuclear-1, consisting of a combination of units with a total capacity 4 000 MW and associated infrastructure for location at one of three potential sites. Similar power stations to Nuclear-1 are proposed for the remaining two sites in the future. A summary comparing the key aspects pertaining to each of the sites is provided in **Chapter 5** while details of the baseline environments at each of the three sites are provided in **Chapter 8**.

The area of the footprint assessed in this EIA makes provision for the potential future expansion of the power station, to allow for a total capacity of approximately 10 000 MW. It is estimated that the total area required for the NPS is 31 hectares. In addition to the actual footprint of the power station, there will be two categories of exclusion zone, for emergency planning purposes, around the power station complex. There are restrictions on various forms of development within these exclusion zones. Internationally, exclusion zones associated with the form of technology being considered for Nuclear-1 are 800 m and 3 km, and Eskom is therefore motivating to the National Nuclear Regulator (NNR) for this to be the case for the Nuclear-1. The final decision regarding the size of the exclusion zone, however, lies with the NNR, as per the National Nuclear Regulator Act, 1999 (Act No. 47 of 1999).

The proposed power station complex will include *inter alia* nuclear reactors and its auxiliaries such as:

- turbine halls;
- spent fuel and nuclear fuel storage facilities;
- waste handling facilities;
- intake and outfall structures required to obtain/release water used to cool the process;
- a desalinisation plant;
- transmission and distribution lines;
- roads;
- the high voltage yard; and
- any other auxiliary service infrastructure.

In the event that the proposed project is authorised, it is anticipated that the construction will commence in 2011 with commissioning of the first unit in 2018.

This chapter provides a basic description of nuclear technology and a description of the proposed project in terms of the salient activities comprising the four primary phases associated with the lifecycle of the proposed power station including preconstruction; construction; operation and decommissioning. It should be noted that this chapter provides a description of the proposed project in its entirety in order to portray a relatively complete conceptual understanding of the proposed development.

3.2 Principles of nuclear electricity generation

Nuclear power relies on low enriched uranium and mixed oxide, rather than fossil fuels, as a source of fuel to produce heat. The heat generated during nuclear reactions results from a process called "fission". Fission entails the splitting of nuclei of atoms by even smaller particles, called neutrons. When a relatively large fissile atomic nucleus is struck by a neutron, it splits into two or more smaller nuclei as fission products, free neutrons and heat. Thereafter, the free neutrons trigger further fission, and the fission process continues in a chain reaction.

The splitting of atoms and the subsequent release of energy and neutrons is referred to as nuclear fission.

This process is controlled within the reactor and the energy released is used to heat water and produce steam, which drives a turbine. The turbine is connected to a generator, which produces electricity. Electrical transformers are used to step up the voltage of electricity generated and feed it into the national grid via transmission lines.

Some of the uranium in the fuel is turned into plutonium in the reactor core. The main plutonium isotope is also fissile and this yields about one third of the energy in a typical nuclear reactor. The fission of uranium (and the plutonium generated in the fission process) is used as a source of heat in an NPS in the same way that the burning of coal, gas or oil is used as a source of heat in a fossil fuel power plant. The nuclear fission process is, however, more efficient at producing energy than the use of fossil fuels. Typically, some 44 million kilowatt-hours of electricity are produced from one ton of natural uranium. The production of this amount of electrical power from fossil fuels would require the burning of over 20 000 tons of coal or 8.5 million m^3 of gas (www.world-nuclear.org/info/inf03.html - accessed on 22 October 2009). Nuclear power production is estimated by a variety of sources to emit between 2 and 20 tons of CO_2 per gigawatt-hour (t CO_2 / GWh) of electricity produced (approximately the same as wind power), compared to coal-fired electricity production, which emits around 891 t CO_2/MWh while gas is around 356 t CO_2/MWh. The average amount of CO_2 emitted by nuclear power in Western Europe is estimated at 16t CO^2/MWh for a Pressurised Light Water Reactor (PWR) (Sustainable Development Commission 2006).

3.3 Nuclear terminology

When discussing nuclear electricity generation the following definitions have been used in this report:

- Reactor type: Refers to the main category of nuclear reactor selection. This category includes Light Water Reactor (LWR), Heavy Water Reactor (HWR), High Temperature Gas Cooled Reactor (HTGCR), Pebble Bed Modular Reactor (PBMR), etc.;
- Technology: Refers to the second level to describe a specific reactor. The LWR type can for instance be broken down into pressurised water reactors and boiling water reactors;
- Plant options: Refers to the final plant type that can be purchased from a vendor; and
- Conventional Nuclear: A term used by Eskom only, to distinguish other nuclear options from the Pebble Bed Modular Reactor (PBMR).

3.4 History of Nuclear Power Plants

The nuclear power industry has been developing and improving reactor technology for almost five decades since the first nuclear power station came into operation in the 1950s. Since then the development of the nuclear power generation industry can be summarised as follows (http://www.world-nuclear.org/info/reactors.html: accessed on 25 October 2009):

- There are now some 436 commercial nuclear power reactors operating in 30 countries, with 372 GWe of total capacity;
- Nuclear power stations provide about 15 % of the world's electricity as continuous, reliable base-load power, and their efficiency is increasing;
- Fifty six countries operate a total of about 280 research reactors and a further 220 reactors power ships and submarines;
- Five nuclear power reactors are in long-term shutdown; and

- Forty seven nuclear power stations with a combined output of 41,8 GW were under construction on 01 August 2009 (This figure was 30 on 07 August 2007 and 44 in January 2009).

Several generations of reactors are commonly distinguished in the following manner:

- Generation I reactors were developed in the 1950-60s. The only ones of this generation still in operation are found in the United Kingdom.
- Generation II reactors are typified by the present United States fleet and are in operation in most countries. Koeberg NPS is classified as a Generation II reactor.
- Generation III/III+ reactors are advancements of Generation II reactors largely due to safety enhancements to the Generation II reactors. Power stations using these reactors are currently being constructed in Japan, Finland, France and China. ***It is this generation of NPS that is proposed to be installed for the Nuclear-1 project.***
- Generation IV designs are still on the drawing board and will not be operational before approximately 2025 and will not be evaluated by Eskom at this stage. A South African company, namely Pebble Bed Modular Reactor (PBMR), is currently designing its Pebble Bed High Temperature Reactor (HTR) technology. Other Generation IV reactors include Gas-cooled Fast Reactors (GFR), Lead-cooled Fast Reactors (LFR), Molten Salt Reactors (MSR), Sodium-cooled Fast Reactors (SFR), Supercritical Water Reactors (SCWR) and Very High Temperature Reactors (VHTR).

3.5 Nuclear technology for the proposed power station (Nuclear-1)

Pressurised Water Reactor (PWR) technology (**Figure 3-1**) was chosen by Eskom as the technology to be used for Nuclear-1. The PWR uses light water as a coolant and moderator. Details regarding the various types of reactors (light water and heavy water) and technologies (PWR and boiling water reactors) were described in the Final Scoping Report. Eskom has been using this technology for the past 25 years at Koeberg NPS and is therefore familiar with this technology. The PWR used at the Koeberg was based on a design by Westinghouse of the USA and built by Framatome, a French company. It must be emphasized that Eskom has not decided on a preferred supplier for Nuclear-1 and that any suppliers and power station models named in this report are meant only for reference purposes to provide an indication of a typical power station conforming to Eskom's requirements. Thus, detailed descriptions of the proposed plant are not available. The approach in this EIA process has therefore been to assess a generic nuclear power station design and for the EIA process to specify enveloping environmental and other relevant requirements to which the power station design and placement on site must comply.

Salient features of the Generation III designs are (World Nuclear Association 2009):

- A standardised design for each type to expedite licensing, reduce capital cost and reduce construction time;
- A simple and rugged design, making them easier to operate and less vulnerable, to operational upsets;
- High availability and longer operating life that Generation II reactors - typically 60 years,
- Reduced possibility of core melt accidents;
- Minimal effect on the environment;
- Higher burn-up to optimise fuel use and reduce the amount of waste; and
- Burnable absorbers to extend fuel life.

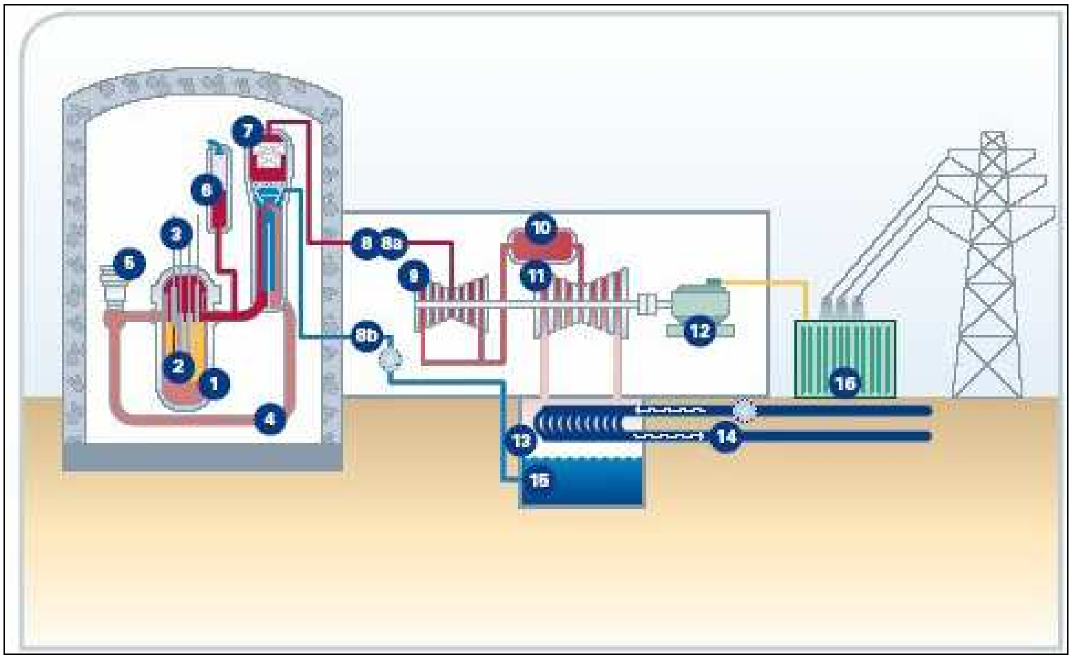

Figure 3-1: Key features of a Pressurised Water Reactor

(1) Reactor, (2) Core, (3) Control rods, (4) Primary circuit (water circuit), (5) Main reactor coolant pump, (6) Pressurizer, (7) Steam generator, (8) Secondary circuit (steam), (8a) Steam for the turbine, (8b) Water for the steam generators, (9) High pressure turbine, (10) Reheater, (11) Low pressure turbine, (12) Generator, (13) Condenser, (14) Cooling circuit, (15) Condensation water, (16) Transformer.

The most significant departure of Generation III designs from second-generation designs is that the former incorporates passive or inherent safety features[1] which require no active controls or operational intervention to avoid accidents in the event of malfunction, and may rely on gravity, natural convection or resistance to high temperatures (World Nuclear Association 2009).

3.6 Operation of a typical Nuclear Power Station

A nuclear power station has a central control room containing all plant operating and monitoring equipment required for plant operation. All major parameters are displayed on large wall screens and there are a number of control desks at which all active components can be manually operated. **Figures 3-2 and 3-3** provide simplified diagrammatic depictions of the nuclear energy process, brief details of which are explained in this section.

3.6.1 Cooling circuits

A nuclear power station using a PWR consists of three main cooling circuits. The water of these cooling circuits does not mix and transfer of heat takes place in heat exchangers. Heat exchangers have two flow paths of water in the device to facilitate heat exchanging between the two liquids.

[1] Traditional reactor safety systems are 'active' in the sense that they involve electrical or mechanical operation on command. Some engineered systems operate passively, e.g. pressure relief valves. They function without operator control and despite any loss of auxiliary power. Both require parallel redundant systems.

The cooling circuits are as follows:

- Primary circuit. The water in the primary circuit flows through the reactor, steam generators and back to the reactor via the reactor coolant pumps. Primary water never leaves the containment building. Water in the primary circuit removes heat from the reactor and disposes this heat in the steam generator. The pressure of this circuit is so high that the water does not boil even at a temperature of 320 ℃.
- Feedwater circuit. The flow path of this water is from the steam generators to the turbines, condenser, feedwater pumps and back to the steam generators. This water boil in the steam generators and is condensed to water in the condenser. The water accumulates energy from the steam generators and disposes of this energy in the turbines and condenser.
- Circulating water circuit. This water is pumped from the sea through the condenser in the conventional island and back to the sea. The NPS use the sea (or a large dam) as the ultimate heat sink.

3.6.2 Reaction pressure vessel

The following information was taken from Ragheb (2008). In a PWR unit **(Figure 3-2**), the coolant is pressurised but is not allowed to boil. The pressurised water is pumped to steam generators where steam is produced and subsequently fed to the turbine plant for the production of electricity. The reactor vessel and the associated steam generators, pressurisers and coolant pumps are enclosed in a containment structure.

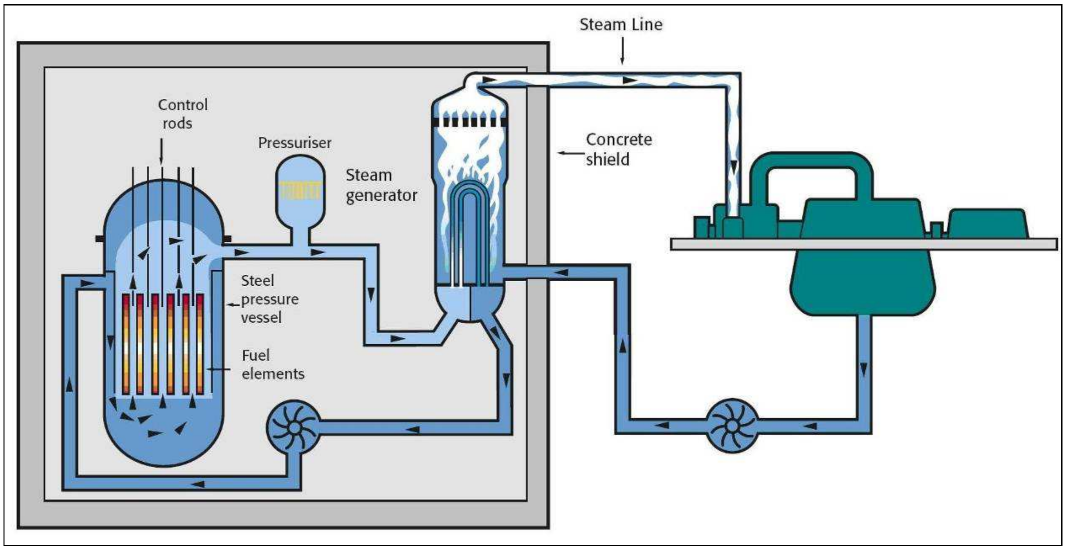

Figure 3-2: Simplified diagrammatic depiction of a Pressurised Water Reactor (PWR)[2] (Ragheb, 2008)

High pressure water is pumped into a pressure vessel containing the reactor core (**Figure 3-3)**. The water flows through an annular region between the reactor vessel containing the reactor core and is subsequently distributed by a nozzle system to the core for cooling the fuel elements. The reactor coolant pumps move the coolant to the steam generators, where steam is produced and fed to the turbine plant. The coolant is condensed in a condenser then fed by the feed water pumps back to the steam generators. The water sourced from the ocean serves as a heat sink for the condenser.

The reactor pressure vessel will be designed to withstand a pressure of 17,1 MPa and a temperature of 351 ℃. The flow rate of the coolant will be between 18 and 33 m^3 per second depending on the thermal power of the reactor. The normal working pressure of the coolant will typically be 15.5 MPa. The hot and cold leg temperatures will be in the order of 330 ℃ and 295 ℃, respectively.

[2] Although the NPS in this figure does not obtain its cooling water from the sea, the principle of its operation remains the same.

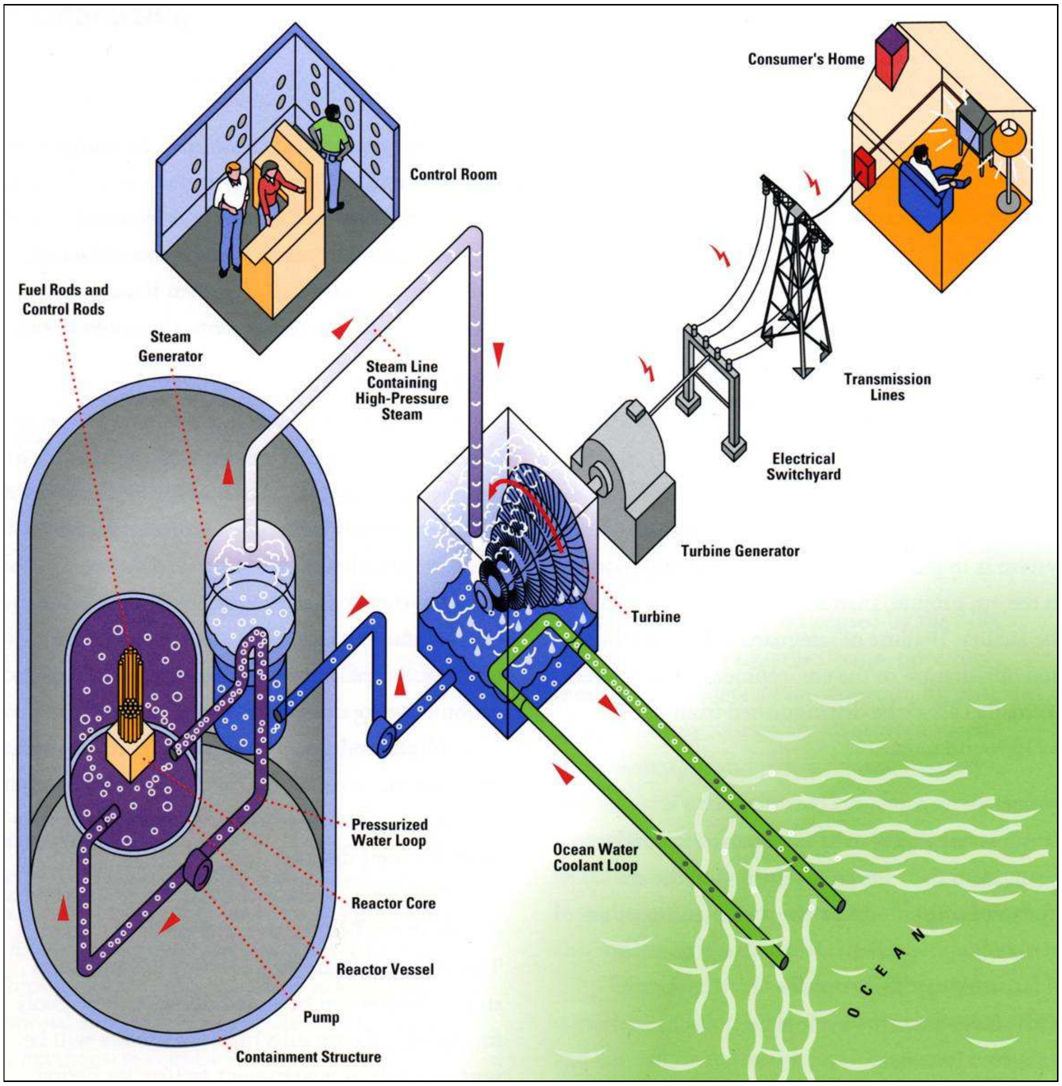

Figure 3-3: Simplified diagrammatic depiction of an NPS

3.6.3 Reactor core and fuel

The reactor core contains fuel material where the fission reaction, which produces energy, occurs. The equipment within the core is used to physically support the fissile material, to control the fission reaction or to channel the coolant. The reactor core consists of a specified number of fuel rods, which are held in bundles by spacer grids and top and bottom fittings. A typical fuel assembly consists of fuel rods arranged in a 17 x 17 or 16 x 16 square array. The fuel rods consist of uranium or MOX (uranium plus plutonium) pellets stacked in a cladding tube plugged and seal-welded to encapsulate the fuel. The pellets are 8.13 mm in diameter and 15.2 mm in length and are enclosed in Zircalloy-4 cladding tube with a wall thickness of 0.635 mm Zircalloy is used as a result of its low neutron absorption, which assists the neutron economy of the PWR (Ragheb 2008).

It is anticipated that for the first five years of operation, Eskom may obtain the enriched uranium from the chosen vendor to allow for immediate utilisation in the reactor. Thereafter, Eskom may source the uranium from local commercial sources. In accordance with the non-proliferation treaty, South Africa does not have facilities to enrich the uranium to produce fuel for an NPS.

The nuclear fuel consists of uranium that is enriched to 4.95 %. Over time, the fuel becomes less effective as it loses its uranium-235 content and fission product (waste) begins to form. The concentration of fission fragments and heavy elements will increase to the point where it is no longer practical to continue to use the fuel. Thus after 12 - 24 months the 'spent fuel' is removed from the reactor. When removed from a reactor, the fuel will continue to emit both radiation and heat. Used fuel is unloaded into a storage pond immediately adjacent to the reactor to allow the radiation levels to decrease. In the ponds the water shields the radiation and absorbs the heat. Used fuel is held in such pools for several months to several years. The spent fuel is then either kept on site *ad infinitum* or permanently disposed at an off-site nuclear waste storage facility. In South Africa, the spent fuel has been kept on site at Koeberg and this is also proposed to be done at Nuclear-1.

3.6.4 Pressuriser

The function of the pressuriser is to establish and maintain the reactor’s coolant system pressure during steady state operation and transients. It also acts as a surge container and water reserve to accommodate the primary coolant volume changes during operation. The pressuriser contains electric heaters in its bottom section, which is normally immersed in water. The operator can activate the electric heaters until the required system pressure is attained. When the system pressure increases, some steam can be condensed by the activation of the water spray from the reactor coolant line, thereby reducing the pressure to normal operating levels.

3.6.5 Steam generator

The function of the steam generator is to transfer the heat from the primary coolant to the secondary feed water to generate steam for the turbine generator set. Steam turns the bladed wheels of a turbine. The turbine is coupled to a generator, which produces energy and together are referred to as the turbine generator set. Steam generators for the PWR design are shell and tube heat exchangers with high pressure primary water passing through the tube side and lower pressure secondary feed water and steam passing through the shell side. In addition to generating steam, steam generators double as a barrier between the primary and secondary coolants. The main steam produced by the steam generators, exits the reactor building via the steam lines, which subsequently enter the turbine building.

If the reactor unit is shut down for longer than a week, keeping the steam generators wet during this period prevents their fabric from corroding and provides a biological barrier (a water shield) when carrying out work in the vicinity of the equipment. In this case, the steam generators are filled with demineralised water, conditioned with hydrazine with added morpholine, ethanolamine or ammonia in the proportions defined in the chemical specifications for the shutdown period. Once the shutdown is over, the solution used for wet lay-up can be drained into the reservoirs or heated directly in the steam generators as the installation restarts. The gaseous effluent from this process is then evacuated to the atmosphere using the turbine bypass.

3.6.6 Turbine

The high pressure, high temperature steam expands and the energy that is released causes the turbine shaft to rotate. All energy from steam is used to drive the turbine. Due to mechanical and ambient losses, approximately one third of the heat generated in the core is converted into electrical energy.

3.6.7 Condenser

The condensers are heat exchangers in which circulating water, obtained from the ocean, flows through numerous titanium tubes. When the steam contacts the cold condenser tubes, the steam is converted into water droplets. The condensers thus convert the steam exiting the turbine back into water and this water is referred to as condensate. The condensate is pumped back to the steam generator where it is heated, evaporated and recirculated through the system.

3.6.8 Electricity generation

The steam turbine drives a generator, which converts the rotational energy of the turbine shaft into electrical energy. The principle underlying this process is electromagnetic induction. When a magnetic field moves past a conducting coil, an electrical voltage is produced in the coil, causing a current to flow in a connected conductor circuit. The electricity generated by the turbine generator set is stepped up via transformers and fed into the off-site grid via high voltage switch gear, housed in the high voltage yard.

3.7 Timeframes for construction

The anticipated timeframes for the proposed developed are indicated in **Table 3-1**. The commencement of site activities will be initiated if and when Eskom obtains all the relevant authorisations. This EIA forms part of the application in terms of the NEMA. In addition, Eskom requires authorisation from the NNR in terms of the NNR Act. Refer to **Chapter 6** for further details outlining the legal requirements associated with the proposed development.

Table 3-1: Estimated timeframes for the proposed Nuclear Power Station

	Start	Complete
Preconstruction	Pending authorisation	2011
Construction	2011	2018
Operation	2017	2078
Decommission	2077	Undetermined

3.7.1 Facilities and activities required for construction to commence

This section provides an indication of the preconstruction planning and some of the activities that must occur prior to the commencement of construction.

3.7.2 Access roads

Existing access routes can be used and upgraded for the Duynefontein and Bantamsklip sites, but the Thyspunt site will require the construction of new access road(s). The Thyspunt site would require two access roads, but three alternative routes are under consideration: an eastern, western and northern access route. The environmental impacts associated with the route identification for Thyspunt's new access route formed part of this EIA process. The relevant specialists assessed the affected areas and provided input into the route determination process. Maps indicating the proposed alternative access routes are provided in **Chapter 5**.

Generally all temporary and permanent services will be routed parallel to access roads. This potential services infrastructure will include:

- Pipes for sand pumping;
- Conveyors to transport aggregate and spoil;
- Water pipes;
- Distribution power lines;
- Communication and data cables; and
- Sewer lines.

3.7.3 Security fencing around the property

The fencing will be of appropriate quality, having taken into account all inputs regarding its fitness for purpose. Based on the faunal specialist recommendations, it is important that the fencing allows for the mobility of faunal species.

The terrace on which the Nuclear Island[3] is situated will be secured with a high security electrified fence referred to as the inner security fence. The off-terrace facilities are also likely to be surrounded by a low security fence referred to as the outer security fence.

3.7.4 Delineation of the Owner Controlled Boundary

The Owner Controlled Boundary places a minimum distance of 100 m between the nuclear buildings and the coastline, in order to ensure the maintenance of coastal corridors along the coastline and reduce the corrosive effects of the marine environment on the power plant. The declared distance from the sea will be at least 100 m. This distance may change on the basis of recommendations from this EIA process.

Access control points will be established at the Owner Controlled Boundary and the inner and outer security fences. The level of security checks performed at the various access control points will depend on the level of the security risk prescribed for the respective area being entered or exited.

3.7.5 Power supply to the site

Power will be required during the construction and commissioning phases. The power will be supplied by means of distribution power lines (up to a maximum of 132 kV) as well as emergency diesel generators. The power sources for the three sites are outlined below. It should be noted that the environmental impacts associated with new power lines do not form part of this EIA and will therefore require separate applications for environmental authorisation. There are three separate EIA applications for the distribution lines that will provide power to each of the three proposed power station sites (refer to www.eskom.co.za). The details of the routes for these lines is, therefore, not discussed in this report. Eskom will supply 5 MVA when vendors access the sites to commence construction, and power supply will peak at about 200 MVA during commissioning. Eskom will endeavour to ensure power availability to the vendors such that construction is not interrupted by power shortages.

3.7.6 Site offices

Site offices will be established either in a developed area, close to the site, or in one of the buildings on the Eskom property. This office will be used to coordinate the ongoing investigations and construction of services, which will provide access to the site for the contractors. Once the contractors are given access to the site, offices for Eskom and the various contractors will be established within the Owner Controlled Boundary for the duration of the construction and commissioning period.

3.7.7 Groundwater monitoring

Boreholes will be sunk upstream and downstream of the power plant once the final layout has been identified. Groundwater sampling will commence prior to construction and will continue throughout the operational phase through to the decommissioning phase. The frequency of the ground water sampling will be determined by the recommendations of appropriate specialists and prescribed in the EMP.

[3] The "Nuclear Island" houses the reactor core and the rest of the nuclear steam supply system.

3.7.8 Development of townships for construction workers and vendor

The development of off-site accommodation facilities do not form part of this EIA process. No onsite accommodation is currently planned. Various options for accommodation are discussed in **Chapter 5**.

3.8 Construction of the terrace and Nuclear Plant

3.8.1 Dewatering

The excavations from the terrace level will be between 15 and 20 m deep depending on the site-specific requirements. The extent of dewatering will be confirmed once the detailed design for the NPS is known. Requirements to which the dewatering process needs to comply will be specified in the EMP, based on recommendations from the relevant specialists.

3.8.2 Excavations

As part of the site preparations for the establishment of the Nuclear Island and the turbine hall, significant quantities of soil and rock will be excavated from the terrace level. Earthworks will involve the removal of the overburden sands down to the terrace level, which may differ from site to site. Further excavation of the overburden will be required around the major power plant buildings down to the surface of the bedrock.

The spoil material may be used to construct rock retaining walls required to stabilise landforms. However, the quantity of spoil required for this purpose is negligible in comparison to the quantity that will be excavated and the majority of the spoil would therefore need to be disposed. This material will have to be stockpiled temporarily prior to disposal. Possible options for disposal of the spoil include:

- On-site storage and rehabilitation;
- Off site spoil area;
- Levelling of HV yard;
- Disposal on surrounding beaches; and
- Disposal and dispersion in the sea as per the recommendations of relevant EIA team specialists.

Chapter 5 provides a discussion regarding the alternative options for utilising / discarding the spoil material.

Undetermined volumes of suitable backfill material may need to be imported to the site. This material can be imported from any source that can provide suitable material, which can either be commercial or material sourced from elsewhere on the site from areas that will be disturbed. A suitable study will have to be conducted to establish available sources. Power plant buildings will be founded on either bedrock or engineered fill, neither of which should be susceptible to large deformations following strong motion earthquakes.

3.8.3 Buildings

The foundations for the nuclear island and turbine hall buildings will be established. Thereafter, the excavations will be backfilled and the buildings will be raised to its full height.

3.8.4 Permanent terrace road and lay down storage area

The permanent terrace road will be constructed to allow for the transportation during construction and operation. Lay down and storage areas will be demarcated to allow for the safe storage of the plant equipment.

3.8.5 Installation of plant

Once the plant material has arrived, the selected vendor will commence with the installation thereof. Transportation of heavy loads required for the construction phase is discussed in **Section 3.12**.

3.9 Associated infrastructure

Table 3-2 provides a summary of the infrastructure that will be associated with the NPS.

Table 3-2: Nuclear Power Station and associated infrastructure requirements

Item	Infrastructure	Brief Description
1	Containment/Reactor building	A containment building is a steel and/or reinforced concrete structure enclosing a Nuclear Steam Supply System. In an emergency it is the final barrier to a radioactive release.
2	Nuclear auxiliary building	Contains Nuclear process equipment associated with the Nuclear Steam Supply System
3	Fuel building	Storage of new and spent fuel
4	Turbine hall	Contains the turbines, generators and associated plant
5	Safeguard building	A building that contains safety equipment
6	Waste building	Temporary storage for Low and Intermediate Level Radioactive Waste
7	Stack[4]	Approximately 96 m tall
8	Diesel building	Houses the emergency diesel generators
9	Diesel storage tanks	Diesel storage
10	Desalination station	Desalinisation of sea water and storage thereof to create potable water
11	Water tank	Water storage container
12	Cooling water pump house	Infrastructure required to deliver cooling water from the intake canal to the condensers and other plant requiring cooling
13	Intake tunnels	Intake tunnels for delivery of cooling water to the intake canal
14	Intake area	Area storing cooling water
15	Outlet tunnel	Cooling water pumped through the condensers and other plant via these tunnels into the sea
16	Chlorination facility	Chemical process plant for production of chlorine
17	Sewage pump station	Underground sumps with pumps to evacuate sewage
18	Sewage treatment plant	Process plant to treat sewage
19	Waste water retention basin	Storage and cleaning of storm water runoff drains
20	Transformer Area	Contains transformers
21	High voltage yard	High voltage switchgear and associated systems
22	Central receiving building	Warehouse and stores
23	Administration building	Offices
24	Training centre	Offices
25	Emergency control and support	Offices

[4] The nature of emissions from the stack is discussed in Section 3.15

Item	Infrastructure	Brief Description
	centre	
26	Estate complex	Offices and workshops
27	Contractor facility complex	Offices, stores and workshops
28	Access control points	Offices and security check points
29	Access Roads	Vehicle access paths to and on site
30	Parking / Lay down area during construction	Temporary storage of heavy plant during construction and parking during operation
31	Visitor's centre	Offices and information centre
32	Helipad	Designated area for helicopter landing and take-off
33	Weather station	Offices
34	Meteorological mast	120 m high steel structure

The key elements of the associated infrastructure are discussed below.

3.9.1 Helipad

A helipad will be constructed in a suitable area and will be used as and when required. It may also be used when the helicopter is required to assist with the lifting of heavy equipment. The helipad will require aviation fuel storage of 5 m^3.

3.9.2 Meteorological station

A meteorological station will be constructed to a height of approximately 120 m. The tower is likely to be of a lattice design. Typically, the meteorological station will undertake measurements of wind, temperature, precipitation and relative humidity, but the exact requirements for the meteorological station will be determined by legal requirements.

3.9.3 Back up power supply

Two diesel generators will be available in the event of a station black out. The back up power supply provides a safety function, as it enables the cooling of the reactors in the event that the main power supply is interrupted. Diesel storage tanks with a capacity of 1 000 kilolitres will be required for this purpose. The backup generators will be tested periodically to ensure they are in good working order.

3.9.4 Visitors centre

Areas will be demarcated for the following facilities covering a total floor area of approximately 1 764 m^2:

- Exhibition area;
- Lobby;
- Cafeteria;
- Information centre;
- Administration offices;
- Meeting room;
- Ablution facilities;
- Storage facilities;
- Auditorium;
- Kitchen facilities; and
- Supporting facilities.

3.9.5 Water requirements

During the construction phase, water is primarily used for the manufacture of concrete in batching plants; earthworks, including the construction of roads; wetting the soil stockpiles to control the generation of dust; and potable water. **Table 3-3** indicates the estimated water consumption during the site establishment, earthworks and construction phases.

Table 3-3: Estimated water consumption during site establishment, earthworks and construction phases

Project Stage	Activity	Unit	Consumption
Stage 1	Site establishment	m^3/day	2 000
		m^3/s	0.023
Stage 2	Earthworks	m^3/day	9 000
		m^3/s	0.104
	Construction	m^3/day	1 600
		m^3/s	0.019

To ensure a constant supply of water to the NPS, the following storage reservoirs will be required on site.

Table 3-4: Reservoirs required on site

Description	Capacity
Demineralised Storage Tanks	4 x 2 200 m^3 + 2 x 800 m^3
Potable Water Storage Tanks	2 x 9 000 m^3
Fire Water Storage Tanks	2 x 1 800 m^3

The capacity of the reservoirs required needs to be approximately 32 million litres. The creation of reservoirs of this magnitude will require separate authorisation from the DWA and the DEA.

Current planning indicates that all water for the construction phase will be derived from the desalinisation plant. However, additional fresh water sources may be required for short periods of time during construction.

3.9.6 Sewage treatment plant

A sewer network will be established and will comprise, as far as possible, gravity flow lines leading to a central sump. The location of the main sewer pump will be chosen based on its appropriateness to the final plant and administrative buildings layout, and based on the recommendations of the specialist studies.

Sewage will be pumped from the main sump to the sewage treatment plant. During construction, based on a maximum of 8 000 people on site, it is estimated that the water consumption will be in the order of 120 litres per person per day. Thus, the waste water treatment plant will be designed to treat 750 m^3 of water per day. The effluent will be treated in accordance with statutory standards in the waste water treatment plant, prior to its discharge into the ocean via outfall tunnels.

The location of the infrastructure will be established once the terrace layout has been finalised.

3.9.7 Permanent and temporary roads

The construction of permanent and temporary roads within the site boundary will commence once authorisation is received.

3.9.8 Desalinisation plant

In order to initiate construction, a portable desalinisation plant will be installed. This relatively small plant will use beach wells for the intake of seawater and will discharge the brine into the breaker zone. Assuming a 40 % recovery of freshwater and operation for 24 hours per day, approximately 17.4 ℓ/s of brine will be generated.

The beach wells are wells sunk into the beach and the water which fills these wells will serve as intake seawater. The sea water intake area will be lined with waterproof material. Assuming a maximum consumption of 9 000 m^3/day as well as a 40 % recovery of freshwater, the required capacity of the seawater intake storage pond will be approximately 45 000 m^3.

A desalination plants three units, each capable of producing 2 000 m^3 of desalinated water per day, will be installed for the operational phase. The intake water will be drawn from intake tunnels from the sea (and / or from the condenser, to improve the efficiency). The intake of sea water for the desalinisation process will be at maximum rate of 9 000 m^3/day, which amounts to 0.14 % of the total volume of water derived from the ocean via the intake tunnels. Assuming a 40 % recovery of freshwater, 260 ℓ/s of sea water will be required as input to the desalination plant, while 156 ℓ/s of brine will be generated. The desalinated water will be stored either in a storage reservoir or a lined pond. The brine (hypersaline effluent) will be disposed into the sea via the cooling water discharge system, to assure instant dilution and disruption of the brine. The salt concentration of the seawater is 35 000 parts per million (ppm) while the brine that is produced is expected to have a salt concentration of 59 000 ppm. The brine and the effluents of reverse washings in the water will be directed to a collection sump. The mixture of water and chemicals will be pumped to a neutralisation pit, which will dilute the salt and chemicals. The diluted mixture will be discharged into the sea, along with the water that was used to cool the reactor.

3.9.9 Demineralisation plant

During operational, water is primarily used for input into the demineralised water treatment plant. Demineralised water is required for use in the NPS as water in its pure chemical state avoids corrosion and the formation of mineral deposits within the system. The demineralisation plant is used to produce filtered water. The demineralisation plant will be composed of two units, each with a capacity to demineralise 2 000 m^3 per day.

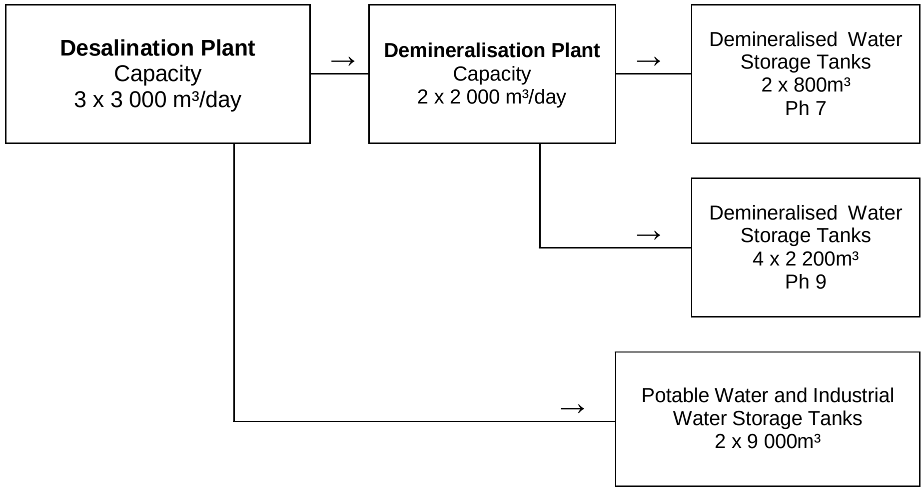

Figure 3-4: Schematic depiction of the desalinisation and demineralisation plants

3.9.10 Chlorination Plant

The chlorination plant will serve to protect the cooling systems against the growth of biofilm and biological fouling (seaweed; marine organisms and debris) through the injection of sodium hypochlorite into the systems. Ordinarily, the sodium hypochlorite is produced *in situ* from the electrolysis of seawater, which occurs in the desalinisation plant. Chlorination is carried out once the temperature of the seawater reaches 12 ℃. The process involves discharging both residual oxidants into the sea (both in the free state and as chlorine compounds) and trihalomethanes (as bromoform).

During normal operation, the cooling systems will receive a continuous injection of sodium hypochlorite at a concentration of two parts per million. In addition, the cooling systems will receive a shock treatment of sodium hypochlorite, at a concentration of four parts per million, three times daily for 15 minutes each.

The effluent emanating from the chlorination plant will be discharged into the ocean via the outfall tunnels along with cooling water.

3.10 Marine works

During operation the power station will require significant volumes of water to cool the process. Water will be obtained from the ocean by means of intake tunnels and expelled via outfall tunnels. In the event that a tunnel boring machine is used, this machine will need to be assembled prior to the commencement of the following activities. The conceptual method of construction is discussed below.

3.10.1 Intake tunnels

An undersea intake tunnel will feed cooling water from the sea into an intake basin adjacent to the cooling water pump houses. No detailed design for the intake tunnel has been done, and the design will comply with the requirements of the relevant specialist recommendations, so as to minimise the impact on marine ecosystems and sediment movement. The following basic principles will, however, apply. The construction of the intake tunnel will involve sinking of a shaft on land to a depth of 25 - 30 m below mean sea level. At this point the tunnel will be driven seawards underneath the seabed. The tunnels will be lined with precast or *in-situ* poured concrete. At the other end of the tunnel, a tower extending approximately five metres above mean sea level will be constructed to connect the intake area and the tunnel. Fixed dredging may need to be installed at the base of this tower. The length of the tunnel from the onshore access shaft will be approximately 1 km to 2 km.

3.10.2 Outfall tunnels

The outfall structures co-dispose the water used to cool the reactors and diluted chemical effluent into the ocean. It is estimated that three to four tunnels approximately 3 m to 4 m diameter each will be required for the outfall works. The marine biologist recommends the use of multiple points in order to facilitate dispersion of the warmed water and mixing with the relatively cooler sea water. The objective of the outfall works will be to transfer the heated water at least beyond the surf zone (estimated to be in the order of 500 m to a depth of five metres below mean sea level). The final depth and distance of release of the heated water will be determined by the recommendations of the marine specialist study. The water released into the ocean be 12 ℃ warmer than the seawater, a s a result of the heat absorbed from the process. The primary objective is to ensure that the heated water does not impact on abalone and other forms of sea life. The velocity of the water in the pipes will fast enough to ensure adequate dispersion into the sea. A high velocity of the expelled water ensures an adequate rate of mixing with the sea water, which reduces thermal pollution of the benthic environment.

3.11 High voltage yard

A high voltage yard (HV yard) will be constructed within the site boundary. When the foundations for the NPS are completed, the high voltage yard will be installed. The high voltage yards form part of the scope the current EIA process for the NPS as they fall within the NPS boundary.

3.12 Materials required for construction

Table 3-5 provides an indication of the quantities of some of the materials that will be used during the construction of the key elements of the NPS.

Table 3-5: Material required for construction of key elements of the NPS*

Activity**	Material	Approximate Quantities	Comment
CONSTRUCTION			
On main terrace; Off main terrace; Marine works; HV yard and transmission lines	Concrete	289 000 m³	Estimated quantities per unit
	Concrete pouring per day	1 000 m³	
	Concrete reinforcing	39 500 t	
	Structural steel	15 213 t	
	Large bore pipe	70 219 m	
	Cable	1 111 001 m	
	Terminations	158 252 each	

Activity**	Material	Approximate Quantities	Comment
	Sand removal	15 000 000m³	
	Bedrock	6 000 000 m³	
On main terrace; Off main terrace; Marine works; HV yard and transmission lines	Concrete	108 660 m³	Balance of plant estimates
	Concrete reinforcing	6 766 t	
	Structural steel	1 299 t	
	Small bore pipe	12 836 m	
	Large bore pipe	163 914 m	
	Conduit	381 256 m	
	Cable	906 884 m	
	Terminations	22 025 each	

*Values are subject to change
** Materials and quantities are applicable to each component

Heavy loads will be transported to and from the closest suitable harbour to the selected Nuclear-1 site. This section discusses the existing road infrastructure as well as the upgrades and / or requirements associated with the transport infrastructure. The management of the transportation of heavy loads should be detailed in a heavy load traffic management plant. All aspects of transport of heavy equipment have been investigated in a detailed traffic impact assessment by Arcus GIBB (2009). This study indicates upgrades that will have to be undertaken on roads to the sites.

3.12.1 Duynefontein

An investigation "Transport Study from Saldanha Harbour to Koeberg Power Station for the Exceptionally Heavy SSC"[12] was undertaken in June 2005. The results of the above-mentioned study indicated that the route from Saldanha to the Nuclear-1 site is a viable option, provided that the route from Saldanha Bay Harbour to the R27 is subjected to several minor road upgrades coupled with an upgrade of the Modder River Bridge.

3.12.2 Bantamsklip

Transport of the exceptionally heavy loads will have to be undertaken from Cape Town Harbour to the N2 and finally the R43 that run through the Eskom property. The distance from the Cape Town Harbour to Bantamsklip is approximately 150 km. An option to use a barge from Table Bay to the site was investigated but the surf is too high and may delay the proposed project.

3.12.3 Thyspunt

The main section of the exceptionally heavy vehicle route will be from Port Elizabeth Harbour, via the N2 and through Humansdorp via the R330 to the site. If the movement of exceptionally heavy loads is required, Eskom will have to undertake a detailed study of the transportation route from Port Elizabeth harbour to the Thyspunt site. However, a preliminary assessment of the route from Port Elizabeth harbour to the site was undertaken as part of this study.

3.13 Operational inputs and outputs

The information provided in **Table 3-6** indicates the anticipated inputs and outputs related to operational phase of the NPS. The amounts are based on a standard reactor, given that the preferred site will play a role in terms of the number of units that the site can accommodate. According to Eskom, the specifications are in line with the European Utility Requirements (EUR) standards for Light Water Reactors (LWR) plants, of which the PWR is an example.

Table 3-6: Inputs and outputs related to the operational phase under normal operating conditions

Activity	Input / Output	Approximate Quantities	Comment
Cooling water	Total cooling water flow (Reactor Coolant Flow Rate)	2 396 736 000 m³/year 196 992 000 m³/month 6 566 400 m³/day 76.0 m³/s	
	Fresh water	2 190 000 m³/year 180 000 m³/month 6 000 m³/day 0.069 m³/s	
Fuel	Enrichment of fuel (by weight)	4.95 %	
	Rods / Assembly	265 each	
	Assemblies / load	241 each	
	Fuel active height	4.20 m	
	Fuel assembly pitch	0.215 m	
	Mass of fuel rod	2.80 kg	
	Mass of assembly	780 kg	
	Total assembly mass in reactor	187.98 ton	
	Duration of fuel in reactor	18 months	
	Spent fuel over lifecycle (Approx)	468 m³	
Water	Demineralised (filtered) water	25 000 m³/year 2 083 m³/month 68.49 m³/day	
	Demineralised water: Spray Packing Glands	40 000 m³/year	
	Turbine Hall	75 000 m³/year	
	Total	115 000 m³/year 9 583 m³/month 315.07 m³/day	

Activity	Input / Output	Approximate Quantities	Comment
	Average drinking water	30 600 m³/year 2 550 m³/month 83.84 m³/day	
Demineralisation Plant	Units Capacity per unit Conductivity of water Silica SiO_2 Sodium Suspended solids	2 each 2 000 m³/day 0.2×10^{-6} S/cm 20×10^{-6} g/l 1×10^{-5} g/l 50×10^{-6} g/l	
Waste	Waste produced (wet solidified, dry compacted or non-compactable)	Detailed information required	< 50 m^3 per 1000 MW plant / year of normal operation (In accordance with the European Utility Requirements for LWR NPS)
Fire water	Storage Tanks	2 x1 800m³	
Chlorination	CRF (Main cooling water): Normal Operation-Continuous Shock (3x/day for 30 min) Continuous consumption rate Shock consumption rate Total consumption rate SEN (Auxiliary cooling water): Normal Operation-Continuous Shock (3x/day for 30 min) Continuous consumption rate Shock consumption rate Total consumption rate	 2.00 mg/kg 4.00 mg/kg 13 565 kg 848 kg 14 413 kg 2.00 mg/kg 4.00 mg/kg 656 kg 41 kg 697 kg	
Hydrogen Plant (H_2)	H_2 Plant / Unit (Nm^3/h @ 25Bar) 4 x Storage Tanks (Nm^3)	15 30	
Auxiliary Steam Boiler	Auxiliary Steam Boiler (x3) (t/h) Diesel Storage Tanks (x2) (m³)	32 230	
Radiation effluent	Discharge	*Limit to be set by the NNR*	Will be established by the NNR
Non-radioactive releases	Stack: Gas Location of release point Height of release above ground Vent tip diameter Exit gas velocity (normal) Exit gas velocity (outage) Exit gas temperature (winter) Exit gas temperature (summer) Gas Turbine Exhaust Gas: Exhaust gas mass flow Exhaust gas temperature Gas Composition -	 Ventilation Next to reactor 96.00 m 3.00 m 5.80 m/s 6.35 m/s Ambient °C Ambient °C 85 kg/s 538 °C	

Activity	Input / Output	Approximate Quantities	Comment
	N_2 O_2 CO_2 H_2O Ar SO_2	74.80 % Vol 13.90 % Vol 4.20 % Vol 6.20 % Vol 0.90 % Vol 0.00 % Vol	
Coal	Usage	0.56 ton/MWh	

3.14 Operational and construction waste

Two main types of conventional waste will be created during the construction phase i.e. general and hazardous waste. The waste typically produced during the construction phase is that resulting from the actual construction activities as well as the presence of numerous construction workers, who will generate domestic waste. Waste materials arise during the erection of reinforced concrete structures, installing of equipment and organizing of construction activities (i.e. construction debris, packaging material waste, polluted waste water), the operation of offices as well as the maintenance of vehicles, which generates hazardous waste.

The operational phase will result in the generation of general, hazardous and radioactive waste. This section provides an indication of the management of the waste associated with the construction and operation phase of the NPS, excluding radioactive waste. Types of waste that will be commonly encountered together with an estimation of the total amounts are indicated in **Table 3-7.**

Table 3-7: Typical waste types during NPS construction for a similar plant (Pöyry Energy Oy and Lithuanian Energy Institute 2008)

Type of waste	1 × 1600 / 1700 MW reactor	2 × 1600 / 1700 MW reactors
Paper Glass Packaging waste Metal scraps Tyre scraps End-of-life vehicles Sewage sludge Concrete sludge Lead batteries Contaminated soils Used oils Residual paints, solvents	Total amount: 14 500 t 1 000 – 2 000 t not suitable for further utilization (lower limit) 385 t/month as peak quantity	Total amount: 27 000 t 2 000 – 4 000 t not suitable for further utilization (lower limit) 740 t/month as peak quantity
Drinking and raw water – waste water treatment	730 000 m^3 20 000 m^3/month as peak quantity	1 400 000 m^3 40 000 m^3/month as peak quantity

3.14.1 General waste

Solid waste, excluding radioactive waste, will be transported to and disposed of at permitted off-site solid waste disposal sites. A number of disposal sites may need to be identified depending on the type of materials being disposed of. This waste relates to construction debris generated during building of the power plant and which comprises concrete and steel, as well as domestic waste generated from the canteens on site, which will cater for the construction workers peaking at 8 000 persons.

Solid waste production will rapidly be reached around the end of the first year and during the second year of construction, slowly and steady decreasing thereafter. The total amount of general waste generated every year is expected to be around 450 – 500 tons for one operational reactor unit and 850 – 900 tons if two units will be operational. The exact amounts of these different materials, as well as the shares that will be recycled and placed in landfill will depend on the organisation of the licensed waste management company as well as the site-specific operations.

3.14.2 Non-radioactive hazardous waste

Non-radioactive hazardous waste generated during the construction and operational phases of the power station will include, for example, burnt-out fluorescent lamps, batteries, used oil and chemical effluents. Further constituents will include scrapped electrical and electronic components, batteries, coolants, solid oily waste, solvents and fluorescent tubes and light bulbs. Chemicals used in normal operation are sodium hydroxide and sulphuric acid. The hazardous waste will be sorted, packaged and confined by the contracting company and then transported by a licensed contractor to an appropriately permitted hazardous disposal site outside the NPS site.

3.15 Gaseous emissions

The description of gaseous emissions below is based on Airshed (2010).

Construction phase emissions will be in the form of fugitive dust emissions from general construction activities (clearance, excavation, scraping, road surfaces, etc.) and emissions emanating from vehicles and equipment. Operational phase emissions, on the other hand, will include non-radioactive and radiological materials.

Potential sources of non-radioactive air emissions during the operational phase include:

- Carbon, sulphur and nitrogen oxides in the exhaust gases from engines of the backup electricity generators – these will be switched on only when the main power supply is interrupted and for periodic testing;
- Formaldehyde and carbon monoxide emitted by the insulation when installations go back into operation after servicing; and
- Ammonia discharged as the temperature rises in the steam generators during start-up.

Trace quantities of radiological materials will be released to the environment during the operational phase. The main source these emissions is the gaseous component arising within the coolant circuit. These gases are collected by the gaseous radioactive waste system and held for decay storage in an activated carbon bed delay system. The effluent passes through a radiation monitor and discharges to the ventilation exhaust duct. The gaseous radioactive waste system is used intermittently and it is inactive most of the time during normal operation of the reactors.

The predicted maximum effective doses for all three sites are indicated in **Table 3-8** below.

Table 3-8: Maximum inhalation and external effective dose predicted in the 40 km by 40 km study area for all three NPS sites

Site	Effective Dose (µSv / annum)
Duynefontein	4.07
Bantamsklip	4.60
Thyspunt	11.31

Government Notice No. R 388 of 2009 specifies that the annual effective dose limit for members of the public from all authorised actions is 1 000 µSv, with an additional provision of an annual dose constraint of 250 µSv. The highest predicted inhalation and external effective dose of 11.3 µSv is therefore about 4.5 % of the dose constraint and about 1 % of the annual effective dose limit.

3.16 Operational liquid effluent

The operation of the power station will result in the creation of chemical effluent. The main sources of effluent and the management thereof are discussed further in this section. The distinction is made between radioactive and non-radioactive chemical effluent produced during the operational phase of the proposed development.

3.16.1 Non-radioactive effluent

According to Areva and Electricité de France (2007), chemical substances not associated with liquid radioactive waste are present in the following discharges:

- Discharge produced by the desalinisation and demineralisation plants;
- Sewer discharge, including rainwater, wastewater, oily water; and
- Discharges associated with seawater chlorination treatment.

a) Desalinisation and demineralisation plants

Areva and Electricité de France (2007) state that the demineralisation and desalination units discharge iron, total suspended solids, chlorides, sodium, sulfates, detergents and brine. The maximum annual amounts of discharged chemicals resulting from supplying for example the EPR Unit are shown in **Table 3-9** below. The values are calculated assuming that the desalinisation unit runs continuously, that pre-processing in the current demineralisation unit runs for several hours per day and that the regeneration cycles operate for 40 days per year.

Table 3-9: Maximum quantities of chemical effluent discharged from demineralisation and desalinisation plants in the EPR unit

Substance	Maximum Annual Additional Discharge (kg)
Chlorides	3 616
Sulphates	11 725
Sodium	13 523

It is assumed that the effluent will be treated in the waste water treatment works, prior to its discharge into the ocean, along with the cooling water via the outfall tunnels.

b) Sewer

The chemical substances discharged into the sea via the sewers are specified below:

- Chemical discharge from the treatment plants and individual drainage installations;
- Discharged hydrocarbons; and
- Phosphate and amines.

Chemical discharge from the treatment station is characterised by a Biological Oxidation Demand that will comply with statutory limits. Wastewater from plant could contain hydrocarbons derived from the treatment of on-site scrubbers and oil filters. The hydrocarbon concentration in the discharge will comply with the statutory limit. Phosphate and amine discharge is generally not continuous, but will also comply with the statutory limits.

c) Seawater chlorination

The cooling systems are protected against the development of biofilm and biological fouling by seawater chlorination. This process involves discharging both residual oxidants (both in a free state and as chlorine compounds) and trihalomethanes (in the form of bromoform) into the sea. The effluent will be diluted with the water used for cooling.

3.16.2 Radioactive effluent

According to Pöyry Energy Oy and Lithuanian Energy Institute (2008), the estimated annual liquid waste for the EPR plant type per unit is approximately 8 000 m^3/year per unit.

The main chemical substances associated with radioactive waste discharged by the plant originate from the addition of the following substances in the process (Areva and Electricité de France 2007):

- *Boric acid*: Boron 10 is a neutron absorber mainly used in the primary coolant systems in the form of boric acid to compensate for slow changes in reactivity such as those associated with fuel burn up between the start and end of the cycle;
- *Lithium hydroxide*: this is a base that is used in the primary system to maintain a constant, slightly alkaline pH to minimize materials corrosion of the system. Its concentration is adjusted during the cycle in conjunction with that of the boric acid;
- *Hydrazine*: this is mainly used for its reducing properties;
- *Ammonia*(*): this is a weak, volatile base, used to obtain a slightly alkaline pH in the systems. In normal operation, it is used in the secondary system as an anti-corrosion treatment. During unit shutdown, it is used for wet lay up of the steam generators and mainly in combined treatment – "hydrazine / ammonia";
- *Morpholine*[5]: like ammonia, morpholine is a weak, volatile base used for anti-corrosion treatment in the secondary system. It is used to maintain an alkaline pH in the whole steam-water system;
- *Ethanolamine*(*): like ammonia and morpholine, ethanolamine is a weak, volatile base used for anti-corrosion treatment in the secondary system. It is used to maintain an alkaline pH in the whole steam-water system;
- *Trisodium phosphate*: this acts as a corrosion inhibitor. It is used in alkaline environments, in particular to treat systems in contact with air where volatile treatment cannot be used. The main systems using trisodium phosphate are the component cooling systems and the auxiliary boiler systems;
- *Detergents*: the site uses detergent products in the laundry to wash and decontaminate work clothing used in restricted areas, and also for cleaning the premises; and
- *Metals and suspended solids*: these originate from component wear.

Liquid radioactive effluent will be collected, treated and stored in the effluent storage tanks.

[5] Ammonia, or morpholine (with added ammonia), or ethanolamine (with added ammonia) are used.

3.17 Operational solid radioactive waste

Solid radioactive waste may be categorised into categories as indicated in **Table 3-10**.

Table 3-10: Categories of Radioactive Waste (NNR 2001)

Waste Classes	Typical Characteristics
Exempt Waste	Activity levels at or below levels found in natural materials (natural background radiation levels).
Low Level Waste (LLW) and Intermediate Level Waste (ILW) or a combination	Activity levels above background levels but below those of High Level Waste. These may be long-lived waste (LILW-LL) or short lived waste (LILW-SL).
High Level Waste (HLW)	Spent (used) nuclear fuel if designated to be disposed of as spent fuel, or the residues resulting from the reprocessing of spent fuel.

LLW and ILW will be controlled within the radiological zones of the power plant and will be transported by road to Vaalputs for long-term storage, as prescribed by the Eskom operating procedures. The quantity of waste will depend on the operating procedures in force at the power plant. The proposed power station, similar to the Koeberg power station, will produce levels of LLW, ILW, and spent fuel. LLW and ILW contain radioisotopes, which decay relatively quickly in nuclear terms (30 to 300 years, respectively). Spent fuel produced at both Koeberg and the Safari reactors at Pelindaba decays to very small fractions of its original radioactivity after approximately 1 000 years whilst long-lived waste produced by mining and mineral processing takes longer to decay.

Vaalputs was selected as a nuclear waste disposal site for the following reasons (NNR 2001):

- The area is fairly isolated and has a low population density (approximately 100 persons within a 20 km radius);
- The facility (total area of approximately 1 000 ha) is sited in an area of low rainfall (approximately 74 mm mean annual rainfall);
- There is no surface water except for short intervals after heavy rains;
- The geological formation on this site does not allow the rainwater to penetrate below approximately 0.5 m; and
- The water table is below the bottom of the trenches.

Vaalputs accepted the first consignment of LLW and ILW from Koeberg in 1986, with the current disposal site covering an area of approximately 0.5 km^2. Current production levels of LLW and ILW in South Africa are in the order of 10 - 15 cubic metres per annum.

3.17.1 Low-Level Radioactive Waste

Low-level Radioactive Waste (LLW) may be generated by hospitals, laboratories and industry. It comprises paper, rags, tools, clothing and filters, which contain small amounts of mostly short-lived radioactivity. LLW is not dangerous to handle, but must be disposed of more sensitively than normal waste. In most instances around the world such waste is placed in sealed containers (steel drums) and is normally buried in shallow landfill sites, such as Vaalputs in South Africa (**Figure 3-5**). Based on the extrapolated quantities of LLW generated at Koeberg, the Nuclear-1 NPS is expected to produce 470 steel drums of LLW per annum, based on an output of 1784 KW (i.e. one reactor) (Eskom 2008).

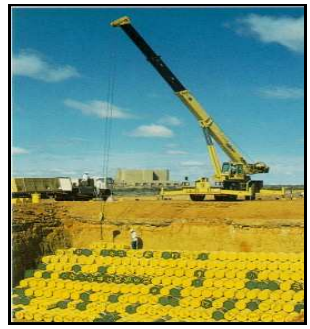

Figure 3-5: Disposal of Low Level Radioactive Waste steel drums at Vaalputs. The drums are covered with layers of clay

3.17.2 Intermediate-Level Radioactive Waste

Intermediate-level Radioactive Waste (ILW) contains higher amounts of radioactivity and may require special containment. It typically comprises resins, chemical sludge and reactor components, as well as contaminated materials from reactor decommissioning. Worldwide this level of waste contributes approximately seven percent of the volume and has four percent of the radioactivity of all radioactive waste. This type of waste is typically combined with concrete or bitumen to solidify it prior to disposal. Again, based on the extrapolated quantities of ILW Waste generated at Koeberg, the Nuclear-1 NPS will produce approximately 160 6.3 ton metal-lined concrete containers containing Intermediate ILW on an annual basis.

3.17.3 High-Level Radioactive Waste

High Level Radioactive Waste (HLW) can either be the spent fuel itself, or the principal waste from reprocessing. While it represents three to four percent of the volume of all radioactive waste, it holds 95% of the total radioactivity. It contains the highly radioactive fission products and some heavy elements with long-lived radioactivity. It generates a considerable amount of heat and requires cooling, as well as special containment during handling and transport. If the spent fuel is reprocessed, the separated waste is normally vitrified (a process in which it is combined with glass), which is sealed inside stainless steel canisters for eventual disposal deep underground. HLW is highly radioactive and thus people handling it must be shielded from radiation. Such materials are transported in special containers, which block the radiation and which are designed not to rupture in the event of an accident.

The South African Cabinet approved a National Radioactive Management Policy and Strategy in 2005. The Department of Minerals and Energy (DME) is currently drafting legislation to implement the policy. The radioactivity of some of the materials in HLW decreases back to natural levels within relatively short periods of time. Other materials, however, remain radioactive for several thousands of years. Hence, there is the need to dispose of HLW in deep geological disposal facilities where it is isolated from the environment. Two options for the long-term management of spent fuel are possible: (a) direct final storage of the spent fuel in a deep underground geological storage facility, or (b) reprocessing of the spent fuel to extract unused uranium and plutonium for re-use and concentration and storage of the residual (about 3 – 4 % of the spent fuel) high level waste in a deep underground geological storage facility. Both options are pursued internationally.

For the proposed Nuclear-1, Eskom intends to follow the practices discussed above for the management of radioactive waste, under the regulatory control of the NNR and subject to the requirements of the National Radioactive Waste Management Policy and Strategy and any associated legislation or regulations. At present, South Africa does not have an authorised facility for the disposal of spent fuel and high-level radioactive wastes. Thus, the producers of such waste (Koeberg and Safari) are required to store the waste at the plant until a national policy surrounding the disposal of nuclear waste is finalised. Similarly, the new NPS will store HLW on site.

To ensure that the performance of a reactor is optimised, approximately one-third of the spent fuel is removed every 12 to 18 months and replaced with new fuel. When the spent fuel is removed from the reactor, it is highly radioactive and hot, and must therefore undergo cooling and be shielded from people. It is therefore placed in storage ponds at the reactor site. The storage ponds are steel-lined concrete tanks, approximately eight metres deep and filled with water. The heat and radioactivity decrease over time, and after about 40 years the heat and radioactivity is reduced to about 1/1 000th of what it was when initially removed from the reactor.

In South Africa, where spent reactor fuel is currently not reprocessed, all the highly radioactive isotopes remain in the assembly. As a result, the whole fuel assembly is treated as high-level waste. Spent fuel handled in this manner constitutes nine times the volume of equivalent vitrified high-level waste resulting from reprocessing and is encapsulated-ready for disposal. Alternatives to treating the waste, such as the reprocessing of spent fuel has not occurred in South Africa to date.

The amount of spent nuclear fuel estimated from the NPS over its life cycle is estimated at 1 880 tons.

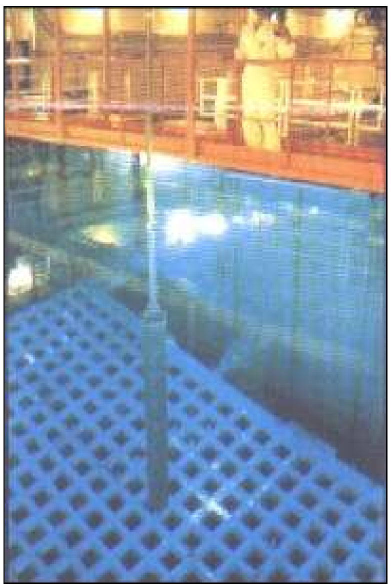

Figure 3-6: High level waste stored on site at Koeberg NPS

3.18 Transportation of solid radioactive waste

South Africa is a member state of the International Atomic Energy Agency (IAEA) and therefore subscribes to the Transport Regulations set out by the IAEA for the safe transport of radioactive materials. Transportation of radioactive materials will be controlled in South Africa by the NNR and this section is merely included in as information to the general public. The IAEA published a series of documents defining the safe conditions for transport for all types of radioactive material and includes a detailed description on packaging, labelling as well as safe transportation requirements. The objective of the IAEA Transport Regulations is to "protect persons, property and the environment from the effects of radiation during the transportation of radioactive material" (NNR 2005). This is achieved by making recommendations with regards to the methods of containment, shielding and prevention.

Explanations thereof are presented below (NNR 2005):

- Containment refers to the correct packaging of the different categories of radioactive material to prevent loss of material;
- Shielding refers to the manner in which one controls the external radiation dose at the package surface to acceptable levels; and
- Prevention refers to limiting the chances of exposing the material to criticality and exposure to heat related damage.

The existing truck and trailer at Koeberg can accommodate 80 steel drums and three concrete drums. The mass of a steel drum can range between 50 and 100 kg while the mass of a concrete drum is 6.3 tons. According to Eskom, radioactive waste will not be transported to Vaalputs during the school holidays and during the rainy seasons. Chapter 5 assesses the various routes available from each of the three sites to Vaalputs and provides recommendations pertaining to the most suitable route for the transportation of the radioactive waste.

3.19 Safety

Since the commercial use of nuclear energy to generate electricity began, it has arguably proved to be one of the world's safest energy generation technologies. This may in part be attributed to the fact that safety forms a major component of the design, construction, operation and decommissioning of a NPS. There are a number of systems that monitor, control, and support the safe operation of the reactor at each power plant. These systems provide maximum safety and reliability and reduce the chance of an accidental release of radioactivity into the environment. This section provides a brief description of general safety considerations, nuclear emergency planning zones, occupational and public exposure as determined by the NNR.

3.19.1 General safety considerations

The design of a nuclear power station incorporates many physical barriers that protect against the accidental release of the nuclear fission products, which become both hot and radioactive during its use. These barriers include the ceramic form of the fuel pellets; the metal encasing of the fuel pins, the reactor vessel with some 25 cm thick walls of steel and a containment building with a lining of steel and walls of reinforced concrete (www.uic.com.au/nip14.htm).

The decade-long tests and analysis programmes show that less radioactivity escapes from molten fuel than initially assumed, and that this radioactive material is not readily mobilized beyond the immediate internal structure. Thus, even if the containment structure that surrounds all modern nuclear plants ruptured, it would still be highly effective in preventing the escape of radioactivity (www.uic.com.au/nip14.htm).

There are numerous safety systems that have been engineered to assist in preventing an accident with the reactor or to reduce the effects in the event that an accident should occur. All critical safety systems have backup systems that duplicate the jobs that the system is supposed to perform. An example of such a backup system would be the large stainless steel pipes of approximately 600 mm in diameter, which carry water to the reactor core, where it cools the fuel. Should these fail for some reason there are a number of other independent emergency cooling systems, included in the design of the plant, which can provide the necessary cooling.

Another key aspect to consider when looking into the safety of a nuclear power station is the training and preparedness to which the people who operate these stations are exposed. For example, reactor operators are trained and tested on the procedures and administrative processes of power plant operation, and in order to train such staff, utilities around the world use sophisticated power plant simulators, which are replicas of the control room of the real power plant in which they will be working. The simulators are computer controlled, allowing the operators to gain practical experience in managing all types of normal and unusual occurrences without posing any danger to the public or the environment.

The nuclear industry throughout the world has rigid safety standards. In South Africa these standards are set and regulated by the NNR, and Eskom has to prove to the NNR that the proposed plant can and will meet these stringent safety standards. Periodic inspections also ensure that each facility operates safely.

It is a misconception amongst the general public that a nuclear reactor can explode like an atomic bomb. This cannot happen, as a nuclear explosion requires a very high enrichment of fissile uranium, which is not the level of enrichment that is found in a nuclear power station. The uranium used is generally enriched below five percent, whereas an atomic bomb using uranium is enriched above 90 percent.

3.19.2 Nuclear emergency planning zones

All nuclear power stations are required to have emergency plans in the event of a disaster and the proposed new NPS will be no exception. At this stage, the exact delineation of the Emergency Planning Zones (EPZs) is unknown. The extent of the required emergency plan and the emergency planning zones will be set according to design and NNR requirements.

EPZs assist in accomplishing the emergency response goals by careful controlling the activities in the region closest to the power station. In order to provide some clarity on the purpose of such zones, the existing Koeberg power station emergency zones are briefly discussed below as an example. Given that the technology of nuclear reactors has significantly improved since the commissioning of Koeberg, it is likely that the EPZ will be reduced in comparison to Koeberg's EPZ. The emergency planning zones for Koeberg are characterised by 5 km and 16 km radii around the power station. The 5 km radius around Koeberg is referred to as the Proactive Action Zone (PAZ) and the zone between 5 - 16 km radius is referred to as the Urgent Protective Zone (UPZ).

It is likely that the corresponding EPZs for the new NPS will be reduced to 800 m and 3 km respectively. The EPZs for the Koeberg NPS should, therefore, be regarded as worst case scenarios, which are unlikely to be applied to the new generation 3 technology. The reduced EPZs are based on European Utility Requirements (EUR) standards, which prescribe that modern nuclear power plants should have no or only minimal need for emergency interventions (e.g. evacuation) beyond 800 m from the reactor. They also provide a set of criteria that a reactor must meet in order to demonstrate that it can be built within such emergency planning requirements.

A group of power utilities from six European countries initiated the commencement of the EUR standards in 1992. The initial intention of the EUR was to agree on a common set of safety requirements with regulators, but later included the development of standardised designs that would be accepted across Europe. Although the EUR standards cover high-level generic safety requirements, they also include some requirements applicable to specific designs, including the EPR design, which is largely based on the EUR standards (Lillington 2004). Further discussion on the EUR requirements is contained in the Emergency Response Report (**Appendix E26**)

The sizes of the EPZs for Nuclear-1 will be determined by the NNRs licensing process.

3.19.3 Security zones

The National Intelligence Agency (NIA) will undertake a security assessment to recommend a security exclusion zone around the power station. This zone is specified to protect the power station from unauthorised access by the public. Currently, there is a security exclusion zone of 2 km offshore from the high water mark specified for Koeberg. Although the recommendations of the NIA are yet to be made, it is assumed that a 1 km security exclusion zone will be specified for Nuclear-1. Access to this area will be subject to a permit application.

3.19.4 Occupational Exposure

The NNR sets the limit of occupational and public exposure arising from operations at nuclear installations in South Africa. The exact radiation exposure, resulting from controlled radiological releases cannot be determined until the final plant is identified.

According to the NNR annual report (2005 and 2006), the regulatory limit for occupational exposure is 50 millisievert (mSv) per annum. For the year 2005, the Koeberg site achieved an individual dose level of 0.9 mSv, which is substantially lower than the approved limits. The highest individual dose accrued at the Koeberg site was 17.2 mSv and the total annual collective effective dose for workers was 2 260 person-mSv (NNR 2005 and 2006). The highest annual individual dose accrued during 2008 was 12.6 mSv, compared to 12.5 mSv in 2007 and 20 mSv averaged over five consecutive years up to 2009 (NNR 2009). These figures indicate that the levels at which Eskom currently operates its facilities are well within the regulatory limits.

During normal operation, radiation workers are exposed to 0.3 nSv/h when working within 100 m of the NPS. This decreases with distance as follows: 27.0 pSv/h at 300 m and 0.2 pSv/h at 1 000 m. In the event of an incident, the dose rate at 100 m is 2.5 nSv/h. Similarly, the dose rate decreases with distance as follows: 0.2 nSv/h at 300 m and 1.6 pSv/h at 1 000 m.

3.19.5 Public exposure

According to the NNR (2005 and 2006), various gaseous and liquid effluents are produced during the routine operation of a NPS. However, such substances are treated prior to it entering the environment through dedicated clean up systems. These clean up systems reduce the amount of radioactivity in such substances to well within the specified limits. The risk of public exposure from that portion of radiation released to the environment is controlled through the implementation of a radiological effluent management programme. This ensures that the risk that such effluent poses to the public is not significant.

One of the key features of this programme, as implemented at Koeberg power station, is the control of the level of radioactivity in effluent discharges to within the Annual Authorised Discharge Quantities (AADQ). Besides these tests and clean up systems, radiological surveillance of the environment surrounding the power station is conducted, which ensures that strict control is placed over potential public exposure to radioactive releases.

According to the NNR (2005 and 2006), the public exposure to radiation as a result of Koeberg's operations has been less than 20 μSv per annum in general and less than 6 μSv per annum in 2005/6, which is far below the limit set by the NNR (www.nnr.co.za). The public radiation predicted for the proposed NPS during normal operation is 0.1 mSv. In the event of an incident or accident, this increases to 10 mSv.

Radioactivity in liquid and gaseous discharges from the Koeberg power station during 2007 and 2008 contributed a projected total individual dose of 0.004 mSv to the hypothetically most exposed public group. The projected doses, as a result of gaseous and liquid discharges, were 0.00047 mSv and 0.0038 mSv respectively for 2008 (0.00094 mSv and 0.003 mSv respectively for 2007), which is well within the NNR limit of 0.250 mSv per annum (NNR 2009).

3.20 Human resources

The personnel required during the various phases of the project differ. This section provides an indication of the labour and staff required during the construction and operational phases as well as the accommodation and transport requirements associated therewith. It is important to note that the number of vendor construction and Eskom operational staff will vary considerably depending on the plant type chosen for Nuclear-1. The figures below indicate maximum values.

3.20.1 3.20.1 Construction personnel

During construction, it is estimated that 5 000 vendor construction workers will be on site. In addition, there will around 2 200 vendor staff, 1 385 Eskom operation staff, 140 Eskom project staff and 40 Eskom consultants present on site.

3.20.2 Operational personnel

According to the Eskom (2008) the operation of an NPS requires a staff of up to 1 385 Eskom Operations personnel[6], who collectively have a variety of scientific, engineering and other technical backgrounds in fields required to effectively and safely operate and maintain the plant. The required skills include *inter alia* the following: nuclear operators, maintenance, nuclear engineering, instrumentation and control, electrical engineering, mechanical engineering, radiation protection, chemistry, emergency preparedness, safety analysis and assessment.

There is also a requirement to have access to national or international expertise to support the NPS operating organisation and regulatory body in terms of specialised scientific areas such as neutronics, physics and thermo hydraulics and other technical areas such as radiation protection, radioactive waste management, quality management, maintenance and spare parts management (IAEA 2007).

3.20.3 Accommodation

According to Eskom (2008) the details of the proposed accommodation required for the Nuclear-1 NPS is as indicated below. It must be emphasised that the accommodation requirements do not form part of this EIA and will therefore require a separate application for environmental authorisation, if required. The accommodation required for the project is summarized in **Table 3-11**.

Table 3-11: Accommodation requirements per NPS site

Description	Units
Vendors Construction Village for Migrant Workers	3 750 Beds
Vendor Staff Village	2 172 Units
Eskom Nuclear-1 Project Team	220 Units
Eskom Power Station Operational Team	1 000 Units

[6] It is assumed that only 1000 will require Eskom accommodation.

The number of beds indicated above for the vendor's construction village was reduced by 25 % to allow for labour sourced out of the local community. The project thus aims to provide accommodation for 1 400 staff members, to prevent over-supply as some of the staff may be married couples, workers from the local community and workers that may prefer private accommodation. The minimum land requirements for the accommodation are estimated in **Table 3-12** below.

Table 3-12: Minimum land requirements (hectares) required for accommodation

Description	Area (hectares)
Vendors Construction Camp for Migrant Workers	50.9
Vendor Staff Village:	89.5
Eskom Nuclear-1 Project Team	12.0
Eskom Power Station Operational Team	65.7
Sport and Recreation Facilities	18.0
Schools with sport facilities (3)	55.0
Total area of land required	**291.1**

The construction camp for migrant workers will typically have the following facilities:

Housing

- 12 bed units (73 %);
- 8 bed units (27 %).

Support facilities

- Bus Terminus and parking laundry;
- Canteen;
- Lapa with TV;
- Liquor outlet;
- Administration office;
- Clinic; and
- Sewage treatment.

Typical recreation

- Tennis (x4);
- Basketball (x4);
- Soccer (x2);
- Rugby (x1);
- Swimming pool (x1); and
- Cloak rooms and ablutions.

The areas of the land will be finalised in terms of the residential densities prescribed by the Spatial Development Plan for the properties that are available. Eskom must provide rezoned land for the vendor to build a construction village for migrant workers. It will be Eskom's responsibility is to facilitate the EIA processes for these facilities.

In addition, Eskom may provide serviced residential stands for the vendor to build staff accommodation. The accommodation will be finalised once the vendor is appointed. The land development will be included in the overall community integration strategy for the Eskom residential developments. It is also possible that Eskom will rent accommodation for the vendor staff from the community / developers.

The continuous construction of further phases of power plants could result in the use of the Vendor’s accommodation for a period of 10 to 15 years to accommodate contractors and may even be expanded during this period. The accommodation facilities will be upgraded and handed over to Eskom in good condition at the end of each contract.

3.20.4 Transport

Eskom will provide public transportation for the construction workers.

3.21 Decommissioning of the proposed NPS

Decommissioning of the facility will be controlled and monitored in South Africa by the NNR. It must be borne in mind that the operating life of Nuclear-1 will be 60 years, which is longer than the existence, in total, of the principle of nuclear power generation (the first four electric bulbs were illuminated by electricity produced by a nuclear reactor in December 1951). Just as operating regulations has changed significantly since 1951, it stands to reason that legislation and regulations for decommissioning of nuclear power plants will change as much from practices in place today. What is discussed under decommissioning below is based on current knowledge, legislation and guidelines and much or this may have changed significantly by 2078, the anticipated date of commissioning. What is important however, is firstly to know that the NNR will monitor the process and secondly that the requirements will be more stringent and, thirdly, that the decommissioning processes and techniques will have developed profoundly over time.

When the NPS has reached the end of its viable lifetime approximately 60 years after commissioning, it will be decommissioned. According to the United States Nuclear Regulatory Commission (2000) decommissioning means shutting down the plant and taking steps to reduce the level of radiation in order for the land to be used for other purposes. For nuclear facilities, decommissioning is the final phase in its lifecycle after siting, design, construction, commissioning and operation. It is a complex process involving operations such as detailed surveys, decontamination and dismantling of plant, equipment and facilities, demolition of buildings and structures, site remediation as well as the management of resulting waste and other materials. All activities take place under a regulatory framework that takes into account the importance of the health and safety of the operating staff, the general public and protection of the environment.

The International Atomic Energy Agency (IAEA) technical document series (Nuclear # 1394 2004) notes that careful planning and management is essential in ensuring that decommissioning is accomplished in a safe and cost-effective manner. The IAEA guidelines (2004) state that until the mid 1980s experience associated with decommissioning was scarce, but much has been learnt in the intervening period in all aspects of the discipline. Sometimes the magnitude of the projects was over-estimated and projected costs were believed to be very high. This often gave rise to a slow down, or even failure to start the decommissioning process while on other projects the tasks were underestimated, resulting in errors. With experience, confidence has been gained and there has often been an incentive to publish and make much information available, particularly in the form of lessons learned. Numerous guidance documents have been published, particularly by the IAEA on subjects such as technologies, strategy, safety, waste management, regulation and by other organizations such as the US DOE[7], OECDNEA[8], and the European Commission. Such guidelines should form a useful basis for the decommissioning of the proposed NPS.

[7] Department of Energy
[8] Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA)

IAEA technical document series (Number 1478 2005) provides a detailed understanding of the manner in which a NPS can be decommissioned. The IAEA guidelines (2005) state that when selecting a proper decommissioning strategy in a specific facility, a range of general and site specific factors require consideration, typically, in a multi-attribute analysis. These factors include cost, health, safety issues and environmental impacts, availability of resources as well as stakeholder involvement.

The key considerations that form part of Eskom's decommissioning strategy are as follows:

3.21.1 Decommissioning strategies

Three decommissioning strategies have been defined by the IAEA, namely immediate dismantling, deferred dismantling and entombment. 'No action' is currently not regarded as an acceptable decommissioning strategy and therefore it will not be further discussed.

Immediate dismantling commences shortly after shutdown following a short transition period to prepare for implementation of the decommissioning strategy. Decommissioning is expected to commence after the transition period and continues in phases or as a single project until an approved end state, including the release of the facility or the site from regulatory control, has been reached.

As an alternative strategy, dismantling may be deferred for a period of up to several decades. Deferred dismantling is a strategy in which a facility or site is placed in a safe condition for a period of time, followed by decontamination and dismantling. During the deferred dismantling period, a surveillance and maintenance programme is implemented to ensure that the required level of safety is maintained. During the shutdown and transition phases, facility-specific actions are necessary to reduce and isolate the source term (removal of spent fuel, conditioning of remaining operational or legacy waste) in order to prepare the facility/site for the deferred dismantling period.

Entombment is a strategy in which the remaining radioactive material is permanently encapsulated on site. A low- and intermediate-level radioactive waste repository is effectively established and the requirements and controls for the establishment, operation and closure of waste repositories are applicable.

Although evaluation of the prevailing factors could clearly indicate one of the above-mentioned strategies, constraints and overruling factors may occur in practice, and these necessitate a combination of strategies or exclude one or more strategies from consideration.

3.21.2 Factors influencing the choice of decommissioning strategy

The following are regarded as general factors that have an influence on the selection of decommissioning strategies (IAEA 2005):

a) National policies and regulatory frameworks

- Policy documents that address programmes and directions of the nuclear industry on a national level;
- Legal framework covering regulatory functions and infrastructure as well as requirements and standards pertaining to decommissioning; and
- Authorisation / licensing processes to ensure regulation of the full lifecycle of the facility, in particular regulations for the planning and execution of decommissioning.

b) Financial resources / Cost of implementing a strategy

- Availability of adequate financial resources and funding mechanisms;
- Direct cost of implementing the decommissioning strategy; and
- Indirect costs associated with the strategy (e.g. costs related to stakeholder involvement and social acceptance).

c) Spent fuel and waste management system

- National spent fuel and waste management policy and strategy;
- Availability of facility-specific spent fuel and waste management plans and facilities; and
- Amounts and types of decommissioning waste.

d) Health, safety and environmental (HSE) impact

- Safety / health risks;
- Environmental impacts including impacts associated with the transportation of material / waste;
- Physical status of the facility e.g. expected integrity of buildings over time;
- Radiological and hazardous material characteristics; and
- On-site industrial safety hazard impacts.

e) Knowledge management and human resources

- Availability of suitably qualified and experienced personnel;
- Lessons learned from previous decommissioning projects;
- Operational history and adequacy of decommissioning related information (records, drawings);
- Resources from other operating nuclear facilities either on site or in the country; and
- Reasons for permanent shutdown, if not consistent with the original planning basis (economic, political, accident).

f) Social impacts and stakeholder involvement

- Impacts on local communities from decommissioning processes;
- Public/stakeholders concerns and perceptions; and
- Reuse options for the site.

g) Suitable technologies and techniques

In terms of the existing South African legislation (the EIA Regulations under the National Environmental Management Act), a full EIA will not have to be undertaken prior to the closure and decommissioning of a nuclear power station if the power station was authorised in terms of the same legislation. However, a full EIA will have to undertaken prior to the storage and / or disposal of hazardous waste. In addition, under the NNR Act, decommissioning also requires authorisation by the NNR to ensure that it is performed safely and that radiological standards are adhered to.

The IAEA guidelines (2005) highlight important constraints and conditions that influence the strategy selection and therefore require full consideration within the South African context:

- Inadequate funds;
- Limited or inadequate legal and regulatory frameworks;
- Inadequate spent fuel and waste management systems;
- Lack of skills within the nuclear field;
- Demand for reuse of facility or site;
- Specific issues in case of small nuclear programmes and limited resources; and
- Influence of local economy and social issues.

According to the IAEA guidelines (2005), the process of selecting a decommissioning strategy typically starts by collecting and assessing available data, by considering all potentially influential factors such as applicable regulations, waste routes and associated good practice indicators. A set of possible decommissioning options is subsequently devised together with a preliminary decommissioning plan for implementing each option. These plans can be relatively brief at this stage, but sufficiently well defined that the associated major hazards and risks can be visualised.

The next step is to perform strategy selection studies. During this process, formal decision aiding techniques and ‘workshop’ discussion sessions can be employed. It should be noted that strategy selection studies (even when using formal methods such as multi-criteria analysis) involve aspects that are judgmental and subjective, potentially leaving the conclusions open to challenge. This problem is increasingly being addressed by public involvement (stakeholder dialogue) in the strategy selection process.

The processes of selecting a preferred decommissioning strategy and the subsequent detailed planning are best approached by ensuring that the planning team clearly understands the underlying safety logic. This logic can be applied to each of the possible options (at an appropriate level of detail), as part of the process of selecting a preferred option. The key point is to ensure that there is a demonstrated connection between the facility condition at shut-down, the proposed decommissioning activities, the associated risks in performing these activities, the resultant safety management arrangements and associated costs. For example, analysis of the risks involved logically determines the requirements for such key aspects as additional or modified equipment, staff training, procedures, work instructions, maintenance and security arrangements.

3.21.3 Preparation of a decommissioning plan for Nuclear-1

The National Nuclear Regulator (NNR) has legislated the need for the establishment of a decommissioning plan for nuclear power stations. The decommissioning plan must be submitted before the nuclear authorisation is granted and at such other frequency thereafter as required by the NNR. The decommissioning plan must address all the activities necessary commencing from the cessation of the operation to the point where the nuclear authorisation may be surrendered and the period of responsibility terminated.

Decommissioning of Nuclear-1 does not require a separate EIA process. In terms of the EIA Regulations (Activity No. 23 of Government Notice No. R 386 of 2006), a Basic Assessment process must be undertaken for decommissioning of a number of activities, including a nuclear power station, only for activities that were not authorised in terms of the current EIA regulations. Should the competent authority grant authorisation for Nuclear-1 based on the current EIA process (which includes an assessment of potential impacts associated with decommissioning), then a Basic Assessment process would not be required for decommissioning as it would have been authorised in terms of the current EIA regulations..

The decommissioning plan for Nuclear-1 is likely to similar to the plan for Koeberg NPS. This plan provides for the following key phases of decommissioning:

- ***Phase 1: Preparations***. This phase will be initiated seven years prior to shutdown of the NPS. It includes a detailed list of preparatory functions (e.g. development of a decommissioning project team organisation), investigations and studies (e.g. environmental impact assessment, cost effective feasibility study, compilation of quantities of radioactive material to be released, control mechanisms, and waste characterisation, including a quantitative estimate of the type, amount, and location of important radionuclides at the end of operating life, etc.), procedures and technical specifications (e.g. final shutdown and defuelling sequencing, procedures for occupational exposure control, control and release of liquid and gaseous effluent, processing of radwaste, site security, emergency programmes, and industrial safety), and temporary construction facilities to support dismantling activities (e.g. centralised processing areas to facilitate equipment removal and component preparation for off-site disposal, upgrading of roads to facilitate hauling and transportation, fabricate shielding in support of removal and transportation activities, construction of contamination control envelopes, and the procurement of specialised tooling.)
- ***Phase 2: Plant shutdown and defuelling***. Decisions are made about the final shutdown dates of the units (namely after the winter peaks or at the optimum fuel

utilisation stage) and the detailed final plant shutdown and defuelling plan is implemented.

- ***Phase 3: Implement the spent fuel pool cooling separation plan.*** Following the fuel transfer to the spent fuel pool, the spent fuel pool separation plan is implemented.
- ***Phase 4: Decommissioning operations,*** including the following tasks:
    - Demolition of conventional island and auxiliaries.
    - Safe enclosure preparation.
    - Electromechanical dismantling.
- ***Phase 5: Spent fuel removal and electromechanical dismantling of the fuel building and auxiliaries.*** After 10 years of decay in the spent fuel pool, the last full load of fuel would have sufficiently cooled down to be removed from the pools. The spent fuel is then relocated to dual-purpose casks (storage and transport) for transfer to a national repository[9]. Once the spent fuel pools have been emptied, the plant can be decontaminated and decommissioned in accordance with the plan.
- ***Phase 6: Demolition of remaining structures and site rehabilitation.***

As stated before, the exact contents of the decommissioning plan are unknown at this stage and it would only be finalised if and when nuclear authorisation is granted by the NNR.

[9] South Africa currently does not have a national repository and high level nuclear waste at Koeberg is currently stored on site. Should no national repository be in place by the time that Nuclear-1 is decommissioned, Eskom may have to re-assess Phases 4 to 6 of Nuclear-1's decommissioning plan.