NATIONAL NUCLEAR REGULATOR

For the protection of persons, property and the environment against nuclear damage.

THE NATIONAL REPORT OF SOUTH AFRICA FOR THE SECOND EXTRAORDINARY MEETING OF THE CONVENTION FOR NUCLEAR SAFETY

South African National Report

August 2012

Table of Contents

Executive Summary ... 5
1 Purpose ... 7
2 Background ... 7
2.1 NNR Directives to Eskom and Necsa ... 7
2.2 Response by Industry ... 9
2.3 Overview of the Koeberg Site and Facility ... 10
2.4 Overview of the Necsa Site and Safari-1 Facility ... 11
PART A: OVERVIEW OF ANALYSIS PERFORMED BY SOUTH AFRICA ... 14
1 International Cooperation Initiatives ... 14
2 Role of National Organisations ... 14
3 External events ... 15
4 Design Issues ... 15
5 Severe Accident Management and Recovery ... 16
6 Emergency Preparedness and Post-Accident Management ... 16
PART B: ACTIVITIES PERFORMED BY OPERATING ORGANISATIONS ... 18
1 External events ... 18
1.1 Koeberg NPP ... 18
1.1.1 Overview of actions taken or planned ... 18
1.1.2 Schedule and milestones for planned activities ... 20
1.1.3 Results of these activities and proposed further actions ... 20
1.2 SAFARI-1 ... 22
1.2.1 Overview of actions taken or planned ... 22
1.2.2 Schedule and milestones for planned activities ... 23
1.2.3 Results of these activities and proposed further actions ... 23
2 Design issues ... 23
2.1 Koeberg NPP ... 23
2.1.1 Overview of actions taken or planned ... 23
2.1.2 Schedule and milestones for planned activities ... 25
2.1.3 Results of these activities and proposed further actions ... 25
2.2 SAFARI-1 ... 26
2.2.1 Overview of actions taken or planned ... 26
2.2.2 Schedule and milestones for planned activities ... 27

2.2.3 Results of these activities and proposed further actions............28
3 Severe Accident Management and Recovery 29
3.1 Koeberg NPP 29
3.1.1 Overview of actions taken or planned......................................29
3.1.2 Schedule and milestones for planned activities 30
3.1.3 Results of these activities and proposed further actions............30
3.2 SAFARI-1 31
3.2.1 Overview of actions taken or planned......................................31
3.2.2 Schedule and milestones for planned activities 31
3.2.3 Results of these activities and proposed further actions............31
4 Emergency Preparedness and Response and Post-Accident Management.31
4.1 Koeberg NPP 31
4.1.1 Overview of actions taken or planned......................................31
4.1.2 Schedule and milestones for planned activities 32
4.1.3 Results of these activities and proposed further actions............32
4.2 SAFARI-1 33
4.2.1 Overview of actions taken or planned......................................33
4.2.2 Schedule and milestones for planned activities 33
4.2.3 Results of these activities and proposed further actions............34
PART C: ACTIVITIES PERFORMED BY REGULATOR......................................35
1 External events 35
1.1 NNR's planned activities...35
1.1.1 Review of Safety Standards and Regulatory Practices.............35
1.2 Schedule for planned activities...37
1.3 Assessment of operators activities 37
1.3.1 Review of Koeberg Safety Reassessment................................37
1.3.2 Review of Necsa Safety Reassessment 38
2 Design issues...39
2.1 NNR's planned activities...39
2.1.1 Safety of the Koeberg Power Station.......................................39
2.1.2 Review of Safety Standards and Regulatory Practices..............41
2.1.3 Design Requirements for New Nuclear Installations..................42
2.2 Schedule for planned activities...42
2.3 Assessment of operators activities 43
2.3.1 Review of Koeberg Safety Reassessment................................43

2.3.2 Review of SAFARI-1 Safety Reassessment 43
3 Severe accident Management and Recovery 44
3.1 NNR's planned activities.. 44
3.1.1 Review of Safety Standards and Regulatory Practices............. 44
3.2 Schedule for planned activities 45
3.3 Assessment of operators activities 45
3.3.1 Review of Koeberg Safety Reassessment................................ 45
3.3.2 Review of Necsa Safety Reassessment 46
4 National Organisations.. 47
4.1 Review of National Organisations 47
4.1.1 NNR Self-Assessment 47
4.1.2 Koeberg review... 48
4.2 Schedule for planned activities 49
5 Emergency Preparedness and Post-Accident Management........................ 49
5.1 NNR's planned activities.. 49
5.1.1 National Review of emergency preparedness and response arrangements and capabilities 49
5.1.2 Review of Safety Standards and Regulatory Practices............. 50
5.2 Schedule for planned activities 51
5.3 Assessment of operators activities 51
5.3.1 Review of Koeberg Safety Reassessment................................ 51
5.3.2 Review of Necsa Safety Reassessment 52
6 International Cooperation.. 52
6.1 National activities 52
6.1.1 Integrated Nuclear Infrastructure Review 52
6.1.2 Integrated Regulatory Review Service...................................... 53
6.1.3 Multinational Design Evaluation Programme 53
6.2 Schedule for planned activities 54
6.2.1 Integrated Nuclear Infrastructure Review 54
6.2.2 Integrated Regulatory Review Service...................................... 55
PART D: SUMMARY Table, Conclusion and References 56
1 Summary Table... 56
2 Conclusion 60
3 References.. 61

EXECUTIVE SUMMARY

Following the nuclear accident at the Fukushima Daiichi nuclear power plant in Japan the National Nuclear Regulator of South Africa (NNR) directed nuclear authorisation holders Eskom and Necsa to perform a safety reassessment of the Koeberg and SAFARI-1 nuclear facilities equivalent to the ‘’stress tests’’ conducted internationally.

The aims of the safety reassessments were to:

1) Identify vulnerabilities in the design basis of the facilities,
2) Evaluate the safety margins for beyond design events,
3) Identify necessary modifications, measures and technical features to be implemented where needed to strengthen defence-in-depth and improve safety of operating facilities.

It was noted that Eskom responded to industry initiatives prior to the NNR directive, which resulted in early short term improvements carried out at Koeberg NPP

The NNR carries out effective regulatory control by developing and implementing regulatory standards and practices that are comparable to internationally accepted standards and practices. The regulatory approach of the NNR considers both deterministic and probabilistic principles for the regulatory control and the assessment and verification of safety of the nuclear installations. With regards to the national nuclear regulatory framework, the NNR has consistently imposed deterministic and probabilistic principles as an obligation on the nuclear industry in South Africa. The NNRs regulatory approach has also had significant impact on the design and operation of the Koeberg nuclear power plant, resulting in modifications and accident procedures which are beyond what is typically required internationally.

The safety reassessments conducted have identified certain improvements, to the plants as well as to the regulatory framework, to further improve safety, and inform additional analyses that need to be conducted to confirm the results of the reassessment. Eskom and Necsa are required to implement these in accordance with the timelines agreed by the NNR.

It is further recommended that South Africa should perform a full self-assessment of all Emergency Planning and Response Infrastructures using the IAEA Emergency Preparedness Review (EPREV) and Self-Assessment guidelines.

In response to the directive from the NNR on May 2011, Eskom and Necsa submitted the respective safety reassessment reports in December 2011. The NNR completed a review of the reports submitted and notes the following high level conclusions:

1) The assessments conducted conform to the NNR directive and are in accordance with international practice.
2) The nuclear installations are adequately designed, maintained and operated to withstand all external events considered in the original design basis.
3) There were no findings to warrant curtailing operations or to question the design margins of these facilities.
4) The safety reassessments identified a number of potential improvements to further reduce risk from beyond design basis accidents.
5) As anticipated, given the short timescale for the reassessment, it is recommended that follow-up studies needs to be performed to confirm the conclusions and consolidate the formal licensing documentation and the Safety Analysis Report of the Nuclear Installation.
6) The NNR has identified 5 areas for improvement of the Safety Standards and Regulatory Practices. These areas for improvement will be addressed as part of the current review of the national Regulatory Framework project.

1 PURPOSE

The purpose of the document is to present the South African response to the Fukushima Daiichi accident. This National Report document details the initiatives undertaken in response to the event.

The report further summarises the outcome of the safety reassessments that have been performed on the Koeberg Nuclear Power Station and the SAFARI-1 Research Reactor and lists the findings and response of the National Nuclear Regulator (NNR) on the respective safety reassessments. Improvements on strengthening the Regulatory Framework are also presented and recommendations made that should be implemented by the NNR.

2 BACKGROUND

2.1 NNR Directives to Eskom and Necsa

The NNR in response to the event a Task Team was established in April 2011 with the objective to:

1) Identify the lessons learnt from the accident.
2) Conduct a comprehensive review of regulatory processes and regulations to determine whether the NNR should strengthen its regulatory oversight system to ensure continuous safety of operating nuclear installations in the country.
3) Conduct a comprehensive review of the safety of existing nuclear installations.

Considering that the prime responsibility for safety rests with the operators of nuclear installations, it is therefore the operators' responsibility to perform the safety reassessment. In this regard, the NNR has directed the operators of nuclear installations in South Africa namely Eskom and the South African Nuclear Energy Corporation (Necsa) to perform safety reassessments on the Koeberg and SAFARI-1 nuclear installations respectively considering the lessons learnt from Fukushima.

The scope of reassessment covered, but was not limited to, the following:

a) **Provision taken in the design basis** concerning flooding, earthquake, other extreme natural phenomena and combinations of external events appropriate to each nuclear installation site.

b) **Robustness of the facility design** to maintain its safety functions beyond the design basis hazards

(i) Earthquake exceeding the design basis
(ii) Flooding exceeding the design basis
(iii) Other extreme external conditions challenging the specific site safety
(iv) Combination of external events

c) **Consequential loss of safety functions**
(i) Prolonged total loss of electrical power
(ii) Prolonged loss of the ultimate heat sink

d) **Identification of potential cliff edge effects** in assessment of external events and safety functions in b) and c) and potential measures or design features to mitigate these effects.

e) **Accident management**
(i) Availability and reliability of accident management measures (Emergency diesel generators, hydrogen management, cooling, reliance on battery power, Emergency Operating Procedures and Severe Accident Management Guidelines, instrumentation, etc.) specifically considering events that potentially impact multiple facilities
(ii) On site response (facilities, resources and training)
(iii) Training of reactor operators for severe accident scenarios

f) **Emergency management and response**
(i) Emergency management actions and preparedness following worst case accident scenarios (Offsite response, arrangements and availability in emergency situations)
(ii) Radiological monitoring following nuclear accident involving radiological releases
(iii) Public protection emergency actions
(iv) Communication and information flow in emergency situations

g) **Safety considerations for operation of multi units** at the same facility site (facilities and resources)

h) **Safety of other fissile material and facilities**, e.g. safety of spent fuel storage in severe accident scenarios

2.2 Response by Industry

It is required that operating facilities consider experience feedback from other utilities in the design and operation of nuclear installations. Eskom proactively established an External Event Review Team (EERT) using the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO) guidelines focussing on design basis, beyond design base and severe accidents arising from external events and predominantly addressing plant equipment, people, procedures and nuclear safety culture. The EERT approach was to assess the design base readiness by a review of system health indicators as well as a review of all non-conformance reports, operability determinations and temporary alterations. In terms of the beyond design bases the approach was to verify:

1) Through test or inspection that equipment designed for severe accident mitigation is available and functional
2) Through walk downs or demonstration that procedures to implement severe accident mitigation strategies are in place and are executable
3) Qualifications of operators and the support staff needed to implement the procedures and work instructions are current
4) Applicable agreements and contracts designed as contingencies to support severe accident mitigation are in place and functional.

A number of initial findings have been made and immediate, short term and longer term initial corrective and mitigation have been identified including amongst others the review of the seismic hazard as part of the new build siting process and the review of tsunami hazard by oceanography consultants. Work completed includes additional testing and maintenance of equipment. Eskom has also procured additional fire fighting equipment. The procurement of larger items is in progress. These include additional diesel powered pumps, electrical diesel generators, an additional fire tender for the site and diesel tankers. Subsequent to the NNR directive issued in May 2011[8] Eskom updated the work scope and approach of the EERT process to address and consider the specific aspects of the NNR directive.

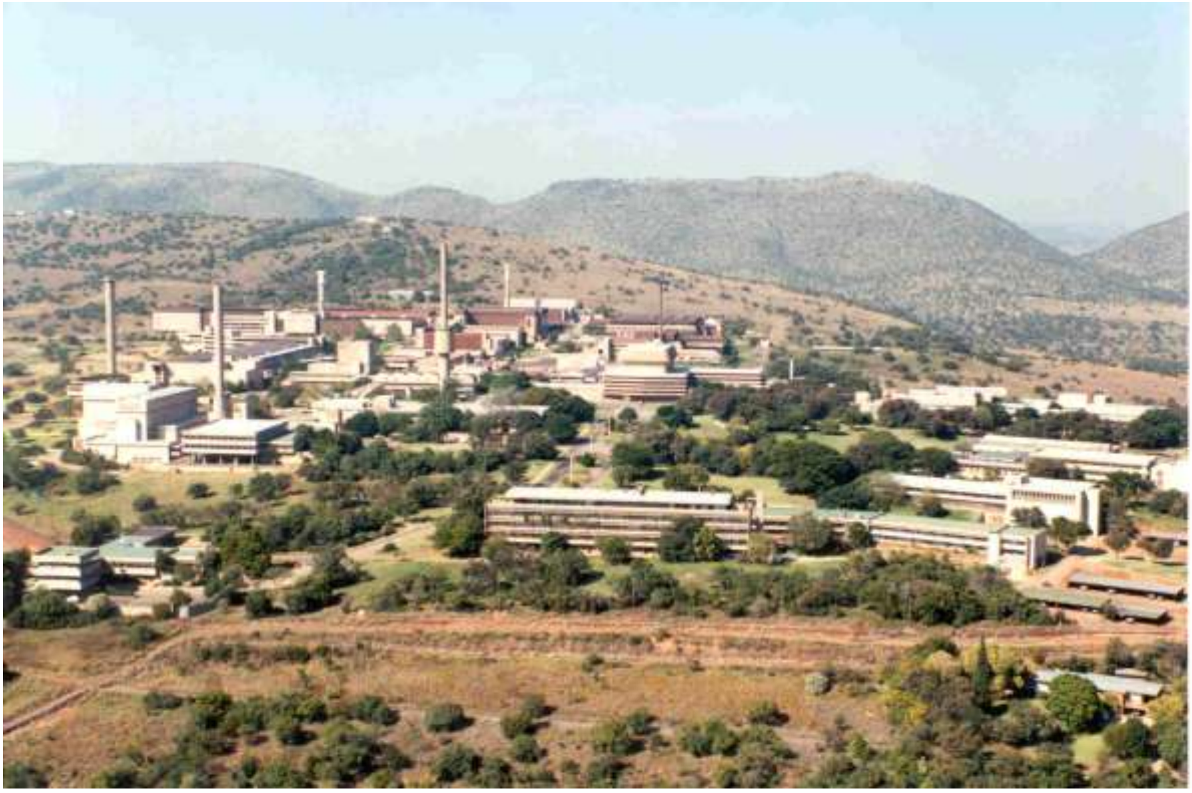
2.3 Overview of the Koeberg Site and Facility

The Koeberg Nuclear Power Plant comprises 2 three-loop pressurised water reactor (PWR) units with their turbine generators and associated plant, each unit designed for a gross fission power output of 2775 MW thermal. The plant is located on the site of Cape Farm No. 34, also known as Duynefontein, in the Western Cape, about 30 km north of Cape Town.

In the PWR design, the water which flows through the reactor core is isolated from the turbine. PWR designs typically have various passive engineered safety features in addition to multiple active engineered safety systems such as the steam driven auxiliary feedwater pump, steam driven main feedwater pump, the design for natural circulation of the primary cooling water, the steam generators with its own secondary water inventory that provides heat sink for a couple of hours (limited) as well as the big containment structure (about 4 times bigger than the typical BWR type containment) and associated free volume. The free volume allows for emergency depressurisation of the primary coolant system in to the containment without necessarily challenging the design pressures of the containment structure itself. At Koeberg passive hydrogen re-combiners have been installed in the containment building to mitigate the consequences of hydrogen production which could result in case of challenges to the cooling of the fuel rods.

2.4 Overview of the Necsa Site and Safari-1 Facility

The site of the South African Nuclear Energy Corporation (Necsa) is depicted in the pictorial below.



SAFARI-1 (South African Fundamental Atomic Research Installation) is a 20 MW thermal tank-in-pool type high neutron flux, light-water-moderated and cooled, beryllium and light water reflected research reactor designed and built as a general research tool. SAFARI-1 falls in the class of research reactors commonly known as Materials Test Reactors (MTRs) and is based on an Oak Ridge Reactor (ORR) design.

SAFARI-1 is owned and operated by the South African Nuclear Energy Corporation (Necsa), located at Pelindaba ~40 km West of Pretoria. The reactor first went critical on 18th March 1965 and was originally fuelled with Highly Enriched Uranium (HEU) sourced from the USA.

In 2005 the decision to convert the reactor to Low Enriched Uranium (LEU) silicide fuel was taken. As of July 2009 SAFARI-1 reactor core was fully converted to LEU fuel elements and control rod assemblies.

Other reactors sharing the same basic design as SAFARI-1 are the High Flux Reactor (HFR) at Petten in the Netherlands and the R2 reactor at Studsvik, Sweden. The R2 reactor operated until 2005 and is in the process of being decommissioned. The present operation of the SAFARI-1 reactor is limited, for various reasons (historical, economics and technical), to 20 MW thermal, which is reflected in the operating licence.

SAFARI-1 is utilised as a neutron irradiation facility and for beam line applications. The reactor provides the basis for several services required by Necsa; and isotope production and irradiation services to NTP serving both local and international markets.

While the main isotope currently produced is fission product Molybdenum 99 (99Mo), there are recurring contracts to produce a wide variety of other isotopes as well as the Neutron Transmutation Doped (NTD) silicon for international customers. Various other services are provided to a variety of external and internal (Necsa) customers.

A picture of the SAFARI-1 research reactor external view is given below.

A pictorial of the reactor hall is provided below.

PART A: OVERVIEW OF ANALYSIS PERFORMED BY SOUTH AFRICA

1 INTERNATIONAL COOPERATION INITIATIVES

The National Nuclear Regulator of South Africa (NNR) in the course of carrying out its mandate is committed to fulfil its obligations in respect of international legal instruments concerning nuclear safety. The Convention for Nuclear Safety is one such legal instrument that the NNR governs nuclear installations within its borders with. In respect of international cooperation, South Africa as a members state of the International Atomic Energy Agency (IAEA), actively participates in activities coordinated by the IAEA on a regular basis.

South Africa has Bi-lateral agreements with France, the United Kingdom, Canada, South Korea, and United States of America. The purpose of such agreements is to actualise information sharing on topical regulatory issues related to the safety of nuclear installations.

As part of the review and assessment process undertaken by the NNR, we extracted insights from several international reports on the event that were in circulation.

2 ROLE OF NATIONAL ORGANISATIONS

The responsibility for nuclear and radiation safety rests with the National Nuclear Regulator of South Africa. The NNR performs these functions through means of the objects of the National Nuclear Regulator Act, No. 47, of 1999.

The objects of the Regulator are to provide for the protection of persons, property and the environment against nuclear damage through the establishment of safety standards and regulatory practices;

The Regulator exercise regulatory control related to safety over—

1) the siting, design, construction, operation, manufacture of component parts, and decontamination, decommissioning and closure of nuclear installations; and
2) vessels propelled by nuclear power or having radioactive material on board which is capable of causing nuclear damage, through the granting of nuclear authorisations;
3) exercise regulatory control over other actions, to which this Act applies, through the granting of nuclear authorisations;
4) provide assurance of compliance with the conditions of nuclear authorisation through the implementation of a system of compliance inspections;

5) fulfil national obligations in respect of international legal instruments concerning nuclear safety; and
6) ensure that provisions for nuclear emergency planning are in place.

The Radiation Control Directorate of the National Department of Health regulates the use of fabricated radiation sources and medical radioisotopes through means of the Hazardous Substances Act, No. 15, of 1973.

At present the South African Nuclear Energy Corporation (Necsa) undertakes the safeguards function on behalf of the state also through means of their applicable legislation, Nuclear Energy Act, No. 46, of 1993, that provides for this oversight role.

3 EXTERNAL EVENTS

With the adoption of international safety practices by South Africa the design of nuclear installations takes into account the consequences of external events such as the one experienced by Japan. Due to their very nature, the exact sequence of events, such as the one that challenged the Fukushima Daiichi nuclear power plant is not likely to occur on South African shores. The NNR and operating organisations in South Africa have not been complacent in this regard and have subjected their nuclear installations to the recommended “stress tests” undertaken internationally. In keeping with this approach the entire relevant set of external events has been considered for the Nuclear Power Plant that is operated by Eskom in South Africa. Since the events in Japan resulted in heightened awareness of members of the public of extreme events more diligence is needed to demonstrate the highest level of safe operation for our nuclear installations.

It has been established from the reassessment that there are adequate provisions in Koeberg NPP design to maintain the stations safety functions when challenged by a design basis external event. Adequate safety margins exist in the design to provide robustness in the plant for coping with beyond-design-basis external events. This margin could be increased, in many cases, without incurring significant costs.

4 DESIGN ISSUES

In accordance with the fundamentalist approach of prevention it is also essential that designs are assessed to determine how robust they are to withstand external events. This aspect, unlike a natural disaster, is within the sphere of control afforded by vendors and system designers. The hardening of safety margins during design therefore becomes instrumental to ensure safe operation.

The Koeberg Nuclear Power Plant (Koeberg NPP) is designed in accordance with the French CPK series. As such it was considered appropriate to apply the international stress tests that were used by other European Countries.

Eskom has proposed to undertake design modifications in the short and long term in order to strengthen the plant response against extreme external events

5 SEVERE ACCIDENT MANAGEMENT AND RECOVERY

Severe Accident Management is an essential element of Koeberg NPP operation. Stemming from the accident analysis process a severe accident management procedure is in place to ensure that the consequences of accidents are mitigated effectively. This procedure has recently been revised as part of the periodic safety review process.

The Fukushima Daiichi accident also resulted in the realisation that when undertaking the analysis of severe accidents it would be necessary to take into account a combination of external hazards in the design phase of a nuclear installation.

For the Koeberg NPP it was found that the implementation of accident management measures was derived from insights that we obtained from the probabilistic safety assessment process. Currently the accident management programme has been revisited and revised accordingly. Essential resources and functions required during a prolonged accident have been identified and strategies for mitigation have been put in place.

6 EMERGENCY PREPAREDNESS AND POST-ACCIDENT MANAGEMENT

The NNR has required Eskom to regularly demonstrate its level of preparedness for simulated emergency conditions. The same tool has been applied to Necsa. Post Fukushima has made this element event more portentous. Regular emergency drills are carried out by management in terms of simulated accident scenarios. The Emergency Operating Procedures at Koeberg NPP have been reviewed so that it would ensure that the NPP would have a high level of readiness for a major external event.

The NNR has consistently insisted on restricting developments in the emergency planning zone around Koeberg NPP. Considering the measures taken around the Fukushima Daiichi NPP it is apparent that this control measure has merit.

From a national perspective there is need to ensure the integration and compatibility of emergency plans from other government agencies within South Africa for events such as the Fukushima Daiichi accident. South Africa will benefit from an IAEA mission, namely, the IAEA Emergency Preparedness Review. It will be necessary for the country to undertake the self-assessment process prior to such a mission taking place.

PART B: ACTIVITIES PERFORMED BY OPERATING ORGANISATIONS

1 EXTERNAL EVENTS

1.1 Koeberg NPP

Overview of actions taken or planned

In response to the NNR directive, Eskom submitted their strategy and action plan which were subsequently accepted by the NNR.

Considering the very challenging time lines stipulated in the regulatory communication Eskom developed a project plan that addressed the NNR directive and consisted of three major milestones. These are in broad terms:

1) Collection of input data, reviewing the current capability as well as work previously performed.
2) Perform analysis and complete the development of event trees that will identify weaknesses.
3) Develop strategies for addressing identified weaknesses and compile final reports.

The methodology for undertaking the safety re-assessment started with screening a comprehensive list of all natural hazards and man-made external events that can affect a nuclear power station. The list of hazards and/or events was screened to determine those that may have a significant effect on the safety of Koeberg NPP.

The following external events were "screened in" and were evaluated in detail in the safety re-assessment to determine their impact on the safety of the plant:

- Geological Hazards:
  - seismic
- Meteorological Hazards
  - high winds
  - tornadoes.
- Hydrological Hazards
  - tsunami
  - flooding
  - blockage/damage of water intake – jellyfish and oil spill.

- Man-Made Hazards
  - aircraft crash
  - external explosion
  - external fire – fixed sources
  - release of asphyxiate and toxic gases (on-site and off-site).

The assessment of the provisions in the design basis concerning extreme natural phenomena and events was predominantly undertaken in the response to the Institute of Nuclear Power Operations (INPO) Level 1 Event Reports (IERs) and World Association of Nuclear Operators (WANO) Significant Operating Experience Reports (SOERs) issued post-Fukushima-Daiichi. In addition, plant walk-downs, inspections, and reviews of existing non-conformance reports and operability determinations were undertaken to confirm the safety status of the plant.

The beyond-design-basis assessment focused on external events and hazards of a severity which has not previously been anticipated. The safety re-assessment was not aimed at confirming or re-establishing the external event design input assumptions and analysis for the site, but rather to identify the resilience of the plant regardless of the frequency or intensity of identified external events and hazards. It was carried out with the aim of identifying a set of critical systems, structures, and components that are crucial for controlling an accident situation and preventing the spread of radioactivity into the environment. The assessment was conducted from an assumption that the external events could exceed the design assumptions.

The safety re-assessment was undertaken to identify improvements to the plant and practices that, if implemented, would extend the robustness of Koeberg NPP to withstand external events beyond the existing design basis.

A needs analysis was performed to identify the absolute minimum needs to be met to achieve the following objectives:

- to ultimately prevent fuel damage;
- to minimise off-site releases; and
- to cope with the loss of off-site power and loss of all AC power.

This needs analysis is complementary to the needs analysis for preventing fuel damage focusing on time dependant needs resulting from a prolonged loss of power.

Assessments were undertaken of the actual plant against the needs identified in the needs analyses.

A functional requirements diagram identifying the success paths for the various safety functions was used to perform the reassessment by postulating external events of successively increasing severity until the point was reached when a specific need identified from the needs analyses can no longer be achieved. This is considered to be the cliff edge where fuel damage or uncontrollable release of radioactivity into the environment is inevitable. A reassessment was undertaken of each of the postulated external events that were screened in.

From the results of the reassessments, a number of findings were identified.

Following the same methodology as that described above, the following additional external events will be evaluated in detail in the safety re-assessment to determine their impact on the safety of the plant:

- Cyber-attack
- Solar storms
- Hail
- Lightning
- Steam-line break in turbine hall
- Credible combinations of events
- Extended seismic assessment and
- Internal explosion and fire.

Schedule and milestones for planned activities

Safety re-assessment of Koeberg Nuclear Power Station

The assessments performed under this scope of work were submitted to the NNR during December 2011.

Extension of the safety re-assessment of Koeberg Nuclear Power Station

The additional safety reassessments described above are scheduled for submission to the NNR on 30 November 2012, with the following exceptions:

- The extended seismic assessment and the internal explosion and fire assessments are scheduled for submission to the NNR by April 2014.

Results of these activities and proposed further actions

Results of the safety re-assessment of Koeberg Nuclear Power Station

The Koeberg plant has been adequately designed, and is maintained and operated to withstand all the external events that were considered in the original design base.

Nothing has been found to warrant curtailing its operation or to question the integrated design margins inherent in the current facility.

The assessment identified hardware modifications, additional procedural guidance and training, and also the increased manpower and equipment that could greatly enhance the robustness of the facility to cope with extreme external events. The implementation of these interventions would increase plant safety margins, provide greater flexibility and diversity for accident management and in some cases, will remove or move the identified cliff edges. The provision of portable equipment has been considered as an alternative where plant hardware modifications would not be feasible or have cost benefits. Some portable equipment such as fire pumps, salvage pumps, and diesel tankers is being or has already been procured.

To cope with any challenges from beyond-design-basis external hazards, reliance would have to be placed on non-safety related equipment and plant line-ups that are not ordinarily tried and tested. There is currently no consolidated strategy for the maintenance, surveillance, and testing of some of this equipment for such postulated events.

The station is designed to cope with a loss of off-site power for up to two days and for a station black-out for eight hours. It is recognised that a severe external event could challenge the timely augmentation of off-site support and services, and for this reason, the plant should be capable of surviving a prolonged station black-out or loss of off-site power. Additional reserves of diesel fuel and associated equipment are therefore required to extend the coping time for such postulated events.

The station has adequate water supplies provided the potable water reservoirs (SEP) are intact to supply make-up water for periods in excess of 20 days using the mobile water pump.

The station is built on a terrace that provides adequate margin against a design basis tsunami-induced flood. A flood higher than the design basis, and which comes over the terrace, would render significant safety systems inoperable. In terms of flooding, this represents a cliff edge. Increasing the safety margins against flooding would require modifications to certain equipment and making watertight some rooms housing essential equipment. Proposals for improving the ability of the plant to respond to flooding above the terrace level have been identified.

The plant's design is robust against a seismic event with a significant margin for most of the safety-related equipment. Some housekeeping issues require attention. The fire protection systems for non-safety-related plant equipment are not seismically designed and no reliance can be placed on these systems; alternative measures would therefore be required. Most administration buildings and storage facilities are not seismically qualified.

The collapse of these administration buildings following a seismic event could complicate the station's response to such an event and might impede accessibility to vital recovery equipment and spares.

The current emergency plan would be challenged if faced with an accident of the severity of Fukushima-Daiichi. Certain equipment used in the plan does not have the capability to withstand certain external hazards.

Equipment is stored and temporary buildings are erected on the Koeberg site in a manner which could complicate the station's response to a severe external event, for example by blocking access routes, generating missiles, etc. Equipment that could be vulnerable to wind-borne and tornado-borne missiles were identified that, if corrected, can improve the plant's resilience to high winds and tornadoes.

Training programmes for the operators and emergency plan staff members were found to be up to date, all documentation and authorisations were current, and the training was considered adequate. The staff members' general awareness of the possibility and potential consequences of the postulated severe external events considered in this reassessment is considered to be inadequate. Increased training in sensitivity and awareness is therefore required.

There are adequate provisions in Koeberg NPP design to maintain the stations safety functions when challenged by a design basis external hazard. Adequate safety margins exist in the design to provide robustness in the plant for coping with beyond-design-basis external events. This margin could be increased, in many cases, without incurring significant costs.

<u>Proposed further actions</u>
The proposed further actions include the compilation of additional procedures as well as the enhancement of existing procedures. It has been proposed that incident procedures for specific external events be compiled by July 2015.

1.2 SAFARI-1

1.2.1 Overview of actions taken or planned

A review of external events potentially impacting on SAFARI-1 was performed. Credible extreme natural external events (ENEE) were identified for the stress test on the SAFARI-1 research reactor on the Necsa site:

- Earthquakes
- Tornadoes
- High winds

These events were assessed deterministically, i.e. assuming a sequential loss of the existing lines of defence, regardless of their probability of occurrence. The ultimate objective was to confirm the degree of robustness of the plant and to identify potential cliff-edge effects when faced with the situations that were postulated, the suitability of the existing measures for accident management and, finally, to identify potential applicable improvements regarding both equipment (fixed and portable) and organisation (procedures, human resources, emergency response organisation and use of off-site resources).

1.2.2 Schedule and milestones for planned activities

A stress test report was compiled for the SAFARI-1 reactor according to the ENSREG stress test specification and submitted to the NNR on 30 November 2011.

1.2.3 Results of these activities and proposed further actions

A recommendation regarding the investigation into an early severe weather warning notification system or arrangement has been made. It could be beneficial to alert operators of approaching adverse weather conditions. Certain actions may then be taken, amongst others:

- Ensuring communication between SAFARI-1's control room and the Necsa site Emergency Services.
- Bringing the plant to a safe state before the ENEE strikes.
- Stopping the intake ventilation systems to ensure that a negative pressure difference between the radiological areas and the outside environment is maintained during a severe event challenging the confinement.
- Execution of the plant emergency procedures to take action as required (e.g. evacuating personnel from areas affected by the unavailability of intake ventilation systems).

2 DESIGN ISSUES

2.1 Koeberg NPP

Overview of actions taken or planned

The external event safety reassessments performed resulted in the identification of proposed hardware modifications. These plant design modification proposals require detailed assessment to determine a feasible and integrated plant design modification solution. In order to facilitate this assessment whilst ensuring timeous implementation of plant modifications, the design modification proposals were divided into two categories, namely, short-term interventions and long-term interventions.

Short-term interventions

In order to maintain or restore core cooling, and containment and spent fuel pool cooling capabilities under extreme external events, a plant design modification strategy based on the use of portable, on-site equipment and consumables is being implemented.

The plant modifications required for the use of portable emergency equipment are currently in progress in the project definition phase. This scope of work includes installation of hardened suction and discharge points for portable equipment, as well as associated instrumentation systems and electrical connections. For example, the installation of dedicated hardened flanges to allow for refilling the Auxiliary Feed-water (ASG) and Spent Fuel Pool (PTR) tanks, and the installation of a hardened system taking suction from the potable water storage (SEP) tank with the ability to distribute this water to various locations on the plant. The procurement of the required portable emergency equipment such as pumps, diesel generators, and flexible hoses is in progress.

Additional identified short-term design modifications include the following:

- upgrading both on-site and off-site communication systems, including the satellite phone system, the telephone exchange, the pager system, and the sound phone system;
- strengthening key equipment to improve seismic robustness;
- installing hardened instrumentation systems for critical equipment and locations, this hardened system will ensure indication of a limited number of critical parameters, such as steam generator level, spent fuel pool level providing indication at both the control room and the local spent fuel pool refilling point, containment pressure, core temperature, and primary (RCP) system pressure. The ability to connect to existing unpowered sensors to read them directly using a portable battery and multi-meter system is being considered as a back-up method as well as to provide data of other important but non-critical parameters.
- improving emergency lighting on the plant, and
- constructing a robust portable equipment storage facility.

Long-term interventions

The safety reassessments performed identified hardware modifications that could potentially enhance the robustness of the facility to cope with extreme external events. The implementation of these interventions could increase plant safety margins, provide greater flexibility and diversity for accident management and in some cases remove or extend the identified cliff edges. The identified potential hardware modifications include the following:

- installing filtered containment venting
- providing additional protection to the diesel generators
- providing additional auxiliary feed-water inventory and a diesel-driven auxiliary feed-water pump protected from seismic events and flooding
- upgrading non-safety related buildings
- providing alternative spent fuel pool cooling
- installing a passive thermal shutdown seal on the primary pumps
- providing external connection points in order to power and read critical instrumentation
- making watertight some rooms housing essential equipment
- modifying bund walls, sumps, and drains to protect against flooding; and
- installing an alternative ultimate heat sink.

Schedule and milestones for planned activities

Short-term interventions

The target implementation date for the completion of the installation of the portable emergency equipment plant modifications is May 2017. This is dependent on the actual details of the design selection and review processes.

The target date for the completion of the procurement of portable emergency equipment is September 2013.

Long-term interventions

The project definition phase will be entered into for the task of addressing the findings relating to plant modifications proposed in the completed safety reassessment studies. The project will consist of definition themes that will be packaged into separate projects. The themes that address the external event assessments that have already been completed will be finalised by September 2012. For the external event assessments that have not yet been completed, the themes will be finalised within 6 months following the conclusion of those studies. For all plant modifications that are shown to be feasible, the target date for completion of all implementation work is 2022.

Results of these activities and proposed further actions

Long-term intervention results

The finalisation of the scope of plant modifications will only be possible once the interrelationship between the different proposals have been evaluated further. Further evaluation will identify which proposals will eventually be implemented, what the sequence would be, which events would be mitigated, and to what extent events will be mitigated. Only then can specific proposals be related to the potential solutions.

Proposed further actions

The plant design modification strategy based on the use of portable, on-site equipment and consumables must be supported by the setting out of the operator actions required for the implementation of this strategy. The proposed procedure enhancements include the compilation of the following:

- Portable motor-operated valve power supply procedure
- Portable ventilation fan procedure
- Diesel conservation procedure
- Diesel supply procedure, and
- Damage controller procedures, or extreme damage mitigation guides.

The target date for the completion of these proposed procedure enhancements is July 2015.

2.2 SAFARI-1

2.2.1 Overview of actions taken or planned

The safety reassessment indicates that the following hardware modifications could be investigated to enhance the robustness of the plant against ENEE:

- Provision of an Independent Shutdown Room (ISR), e.g. an ENEE-protected place from which it is possible to shut down the reactor and plant if this could not be done from the main control room. It could also have the capability to monitor certain reactor and plant parameters and provide control of some systems (such as ventilation systems) that may need to be restarted to mitigate the consequences of an ENEE. Conditions which typically could prevent staff from working in the main control room are:
  - High radiation levels (the control room is not shielded from the reactor operational area),
  - Contaminated air entering the control room ventilation system,

- Fire in the control room,
- An ENEE that damages the control room.

- Additional diverse instrumentation: The incorporation of additional dedicated monitoring instrumentation may be an advantage. Instrumentation may include, but is not limited to: independent core monitoring instrumentation, radiation monitors, exhaust air monitoring (all hard-wired to the ISR) and a small portable electrical power supply to operate the instrumentation.
- Increasing robustness of building: The robustness of the SAFARI-1 building can be improved by strengthening the following structural components so that a minimum HCLPF PGA of 0.15 g in the free field can be obtained:

  - Some of the external windows could be in-filled to improve the shear and torsional resistance of the building as a whole.
  - Floor and roof slabs.
  - Roof steel truss support system.

This will also improve the robustness against tornado and high wind events.

- Submersible pumps: It will be beneficial to have a number of submersible pumps at strategic places in the basement and process wing to pump water that has drained from a damaged pool wall back into the pool or reactor core.
- Re-flooding nozzle: The re-flooding of the reactor vessel along the existing re-flooding pathways can be fairly slow. The availability of an additional re-flooding path located in the vessel-top could be an improvement of the re-flooding pathways. The addition of the dedicated re-flooding nozzle could eliminate potential fuel damage due to the loss of coolant accident (LOCA).
- Second shutdown system: An additional diverse shutdown capability independent of the control rods could also eliminate fuel damage in case of a large break LOCA in the reactor primary system subtended by a failure of the normal Scram system.
- Racks in fresh fuel vault: The rack stands could be bolted to the walls and the fuel elements and control rods could be clamped to the shelves to increase the robustness of the vault.

2.2.2 Schedule and milestones for planned activities

All identified modifications for investigation will be considered and a strategy and action plan for possible investigation and implementation will be completed by 22 June 2012.

The investigation will be assessed in an integrated manor, taking the current aging management schedule and projects into account.

2.2.3 Results of these activities and proposed further actions

Further actions and prioritization of these actions will be decided on by taking due consideration of risk and ALARA impacts.

3 SEVERE ACCIDENT MANAGEMENT AND RECOVERY

3.1 Koeberg NPP

Overview of actions taken or planned

Safety re-assessment of Koeberg Nuclear Power Station

The safety re-assessment performed in light of the lessons learnt from the Fukushima-Daiichi nuclear accident was performed with respect to external events, both in the design basis and risk analysis and was to include the following regarding accident management:

- availability and reliability of accident management measures specifically considering events that potentially affect multiple facilities;
- on-site response; and
- training of reactor operators for severe accident scenarios.

A set of needs was developed which focused on the minimum needs that will have to be achieved to meet the objectives of optimising plant recovery.

The needs analysis for determining the resources and functions needed to recover the plant following a postulated and prolonged nuclear accident was undertaken which considered the following:

- cliff edge managing points
- building facilities (including resilience to external events, lighting, and communications)
- tools, spares, and procedures
- local staging of critical equipment
- mobile equipment options, and
- protective clothing and breathing apparatus.

The plant recovery capability was assessed against the identified needs. From the results of the assessments, a number of findings were identified.

Eskom will also be adopting a decentralised approach to ultimate plant recovery. This strategy is based on the assumption that the control room or control systems or both could be lost resulting in plant personnel having to mitigate an event using local control in the field. In order for this strategy to be implemented, Koeberg will be adopting a strategy to man the cliff edge management points, called CEMPs from where core damage can ultimately be mitigated.

Since the accident at Fukushima Nuclear Power Plant in March 2011, the accident management programme at Koeberg has been reviewed to provide assurance that Koeberg is in a high state of readiness to respond to both design-basis and beyond-design-basis events. The actions taken include the following:

- Information gathering and review, with a focus on reviewing the documentation and studies currently in place, identifying the effectiveness and weaknesses of the current strategies, and developing an understanding of the design assumptions that have led to the guidance provided by both the Emergency Operating Procedures (EOPs) and Severe Accident Management Guides (SAMGs);
- Review of the adequacy of the existing equipment testing regime and inspecting the condition of the beyond-design-basis line-ups in the EOPs and SAMGs, to ensure a high degree of confidence that they will function if required during an accident;
- Verification through walk-downs and demonstration that EOP and SAMG strategies are in place and are executable; and
- Verification that the qualifications and training of operators and support staff needed to implement the procedures and work instructions are adequate.

Schedule and milestones for planned activities

The use of portable emergency equipment in conjunction with the planned installation of flanged connections in the existing cooling systems is a reasonable and effective means of utilising alternative sources of cooling water, and increases the flexibility and diversity of accident management. Similarly, the planned installation of terminal panels and junction boxes with electrical cross-connection cabling is an effective means of facilitating the supply of alternative electrical power from other areas of the plant and from off-site sources. This strategy is scheduled for installation on the plant by May 2017, completion of portable equipment procurement by September 2013, and implementation by July 2015.

Results of these activities and proposed further actions

The reassessment performed showed that the accident management programme at Koeberg is generally in a high state of readiness to respond to both design basis and beyond design basis events.

A number of proposals have been made as a result of the findings of the reassessment; these include the following:

- Develop procedures and work packages for local staging;
- Update the technical bases for SAMGs;
- Improve robustness of identified facilities and infrastructure against external events; and
- Procure mobile equipment to move water and diesel, clear debris, and provide power.

3.2 SAFARI-1

Overview of actions taken or planned

The safety reassessment indicated the need for investigating the development of a program providing a combination of pre-ENEE planning (where early warning is feasible) and short and long term post-ENEE actions. The post-ENEE actions could include the compilation of a list of physical inspections and tests to be performed to assess the condition of the plant after an ENEE.

Schedule and milestones for planned activities

The schedule for the development of severe accident management and recovery procedures will be addressed in the strategy and action plan for possible investigation. The strategy and action plan will be completed by 22 June 2012.

Results of these activities and proposed further actions

Further actions will be identified during the cause of the investigation.

4 EMERGENCY PREPAREDNESS AND RESPONSE AND POST-ACCIDENT MANAGEMENT

4.1 Koeberg NPP

Overview of actions taken or planned

<u>Safety re-assessment of Koeberg Nuclear Power Station</u>

In May 2011, the NNR directed Eskom to perform a safety re-assessment of Koeberg Nuclear Power Station. The directive included the following regarding emergency management and response:

- emergency management actions and preparedness following worst-case accident scenarios
- radiological monitoring following nuclear accident involving radiological releases

- public protection emergency actions, and
- communication and information flow in an emergency situation.

A set of needs was developed which focused on the absolute minimum needs that will have to be achieved to meet the objectives of optimising the emergency plan.

The needs analysis for the execution of the emergency plan following a postulated and prolonged nuclear accident that results in an off-site radiological release was undertaken. The following aspects of the emergency plan were considered:

- building facilities (including resilience to external events, power supplies, ventilation and lighting)
- access control and muster control
- exposure monitoring, contamination control, and protective clothing
- medical emergency
- transportation
- food, water, rest, and personal hygiene, and
- communications, documentation, data and information flow, and electronic models.

The emergency plan was assessed against the identified needs. From the results of the assessments, several findings were identified.

Schedule and milestones for planned activities

The studies that were conducted and the subsequent report include proposals to be considered for improving the facilities and procedures for the emergency response preparedness. The findings and proposals related to the emergency plan facilities will be included in the themes that will be identified for overall upgrading of the plant facilities. The last of these modifications will be implemented by 2022.

The report further proposes the implementation of Extreme Damage Mitigation Guides to complement the current set of procedures for use during plant recovery actions. The implementation of these procedures will be further evaluated. The final procedure strategy for the emergency plan will inform any additional procedures to be developed which will be concluded together with the implementation of any additional plant procedures, which is scheduled for completion by July 2015.

Results of these activities and proposed further actions

The personnel impact and staffing numbers required to implement the actions in the emergency plan still needs to be analysed further. The number of personnel needed to implement the plant recovery actions is highly dependent on the assumed event. The methodology for performing such a study therefore still needs some development.

The study also introduced the concept of providing an access control point to the affected area. The requirements and equipment needed at such a point is under consideration and needs to be incorporated into a mobile unit that can be deployed during an accident resulting in off-site releases.

Eskom is also having discussions with other operators to explore the possibility of sharing in the cost of procuring larger quantities of recovery equipment that can be deployed over time. This concept still needs some additional work to establish feasibility.

Several proposals have been made as a result of the findings of the re-assessment, these included developing design bases for emergency planning and preparedness. The adequacy of the emergency plan can be improved with the development of a design basis for equipment used in dealing with severe accidents, the procurement of additional emergency response equipment, the upgrade of facilities and updating of practices and procedures.

4.2 SAFARI-1

Overview of actions taken or planned

From the safety reassessment it has been recommended that a site-wide assessment should be launched to identify all emergency equipment that could be shared between SAFARI-1 and Necsa's Emergency Services, Electrical and Mechanical Maintenance groups. This should be followed by a suitability and compatibility assessment which should include compatibility of connections, available capacity and required demand of essential equipment.

Schedule and milestones for planned activities

The schedule for the assessment of the site-wide compatibility of equipment, capacity and demand of the essential equipment will be addressed in the strategy and action plan by 22 June 2012.
A re-assessment of the technical basis for the Necsa site EPZ has been scheduled for completion by 30 June 2012. The technical basis for emergency planning will consider the insights gained from the severe external event safety reassessment performed for the SAFARI-1 reactor and related identified site emergency planning requirements.

Results of these activities and proposed further actions

The results and proposed actions will follow the completion of these investigations.

PART C: ACTIVITIES PERFORMED BY REGULATOR

1 EXTERNAL EVENTS

1.1 NNR's planned activities

Review of Safety Standards and Regulatory Practices

One of the important lessons learnt from the Fukushima accident is that severe, extreme and combination of external hazards should be considered in the design, mitigation and emergency planning arrangements. This implies that the regulatory standards should include requirements that severe accidents are considered appropriately, specifically as it relates to a common mode failure due to an external event. The NNR reviewed its Safety Standards and Regulatory Practices (SSRP) [16] has identified areas to strengthen the existing set of requirements.

The NNR has consistently imposed risk criteria on the nuclear industry. This effectively imposes the type of requirements referred to above. In this regard the requirements imposed on Koeberg by the NNR go beyond what is typically required internationally, and to large degree already address this lesson from Fukushima. Eskom have already implemented modifications and procedures for the mitigation against severe accidents at Koeberg.

The National Nuclear Regulator Act [7] and the SSRP promulgated under the Act set down overall safety or principal requirements on applicants and holders of the authorisations which must be met to ensure safety of facilities or actions against nuclear risk. These principal nuclear and radiation safety requirements form the basis for the stipulation of the authorisation requirements which are expanded further in a suite of regulatory documents. The principal requirements comprise general requirements to respect good engineering practice, ALARA, defence-in-depth principle and specific radiation dose limits. These are categorised for normal operation and operational occurrences for workers and the public. The safety requirements also stipulate occupational risk limits for the workers as well as risk limits for the public for all possible events that could lead to radioactive exposure.

As early as the middle 1970s, concurrent with the licensing of the Koeberg Nuclear Power Station, the South African regulatory framework required that the safety assessment must include both deterministic and probabilistic safety analyses. The deterministic analysis has to demonstrate the robustness of the design against the design basis or postulated events based on conservative assumptions. This conservative approach adopted for the design basis provided margins for events not necessarily considered in the original design basis.

Existing operating plants would typically consider internal and external events down to a frequency of 1 in 10 000 years.

Section 3.3 of the SSRP requires that a prior safety assessment must be performed to determine the measures to control risk of nuclear damage, to identity all significant radiation hazards and to evaluate the nature and expected magnitude of the associated risks.

Further, section 3.9 of the SSRP states that:

"A multilayer (Defence-in Depth) system of provisions for radiation protection and nuclear safety commensurate with the magnitude and likelihood of the potential exposure involved shall be applied to sources such that a failure at one layer is compensated for or corrected by subsequent layers, for the purpose of,"

(a) Preventing nuclear accidents
(b) Mitigating the consequences of any such accidents; and
(c) Restoring sources to safe conditions after any such accident.

Additionally, it is required in RD-0024 [17] that "*All operating conditions and events which may give rise to risk to the population or workers as a result of exposure to radioactive material on site or released from the nuclear installation must be identified*" and that for the accident conditions identified the following must be determined:

- The average population risk, including the bias against larger accidents, due to the nuclear installation
- The maximum individual risk due to all nuclear installations.

The probabilistic safety analysis therefore has to demonstrate compliance with NNR risk limits and in doing so consider all event scenarios, including combinations of events, and events not necessarily included in the design basis of the facility. Common mode events or multi facility accidents are also from a risk to the public perspective covered by the existing requirements. Based on the insights from the probabilistic safety analyses considerable attention was given to various safety countermeasures for Koeberg that resulted in a number of accident management measures being implemented on the plant.

Overall the NNR standards (SSRP and relevant requirements documents) require that the safety analyses consider all events including extreme external events but do not provide specific requirements and guidance on how to achieve compliance with these requirements.

1.2 Schedule for planned activities

The Regulations will be reviewed as part of the subproject of the NNR Self-Assessment on Regulatory Framework to include specific requirements on common mode external events and combination of events for beyond design basis events.

1.3 Assessment of operators activities

Review of Koeberg Safety Reassessment

The NNR review of the Koeberg safety reassessment concluded that the safety reassessment meets the NNR directive, is consistent with international practice and addresses in broad aspects the objectives as set out by the directive. Eskom followed Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO) directives, and the WENRA definition of stress tests which addressed the immediate needs arising from the response to the Fukushima accident.

Eskom should however complete the outstanding studies and analyses indicated in their report, in so doing also address the NNR findings as detailed below as a matter of priority.

Eskom has been instructed to commit to a list of improvement actions to be implemented in the short, medium and long term.

The review of the Koeberg safety reassessment relating to external events found that:

1) The safety reassessment performed by Eskom on the Koeberg Nuclear Power Station considered the design basis, beyond design basis, accident management and emergency plan measures, identified cliff-edge effects and possible corrective actions in line with the NNR directive.

2) Overall, Eskom appear to have gone beyond the scope of studies performed internationally. Whereas most countries have focussed on flooding and seismic events, Eskom have addressed a comprehensive range of external events.

3) A number of improvement actions and/or recommendations have been identified relating to plant modifications, additional procedural guidance, and equipment that could enhance the robustness of the facility to cope with extreme external events for a prolonged period.

The review of the safety reassessment report has however also found that:

4) Credible combination of events has not been adequately considered in the safety reassessment such as a combination of high winds and precipitation and seismic and consequential fires.

5) The seismic walk downs took place during normal operation when the internal structures of both reactors were not accessible. A number of analysis are still being addressed as part of this report which makes it difficult for one to judge the extent to which this report and the seismic evaluation(s) presented in it can be considered complete.

6) The scope of the assessment did not include other possible common mode external events such as toxic gases and solar flares and other plant vulnerabilities identified in the Koeberg safety reassessment and international reports. These have been deferred to a later stage and were excluded as a result of time constraints.

In addition to the improvement actions identified by Eskom, the following finding relating to external events should specifically be addressed by the holder:

- The potential hazard associated with the hydrogen storage yard should be further investigated as a matter of priority and relevant measures implemented to reduce the threat in line with good engineering practice and a good safety culture.

Review of Necsa Safety Reassessment

The SAFARI-1 safety reassessment was limited to extreme natural external events. The following external events were analysed:

1) Earthquake
2) Tornados
3) High winds
4) Loss of Offsite Power

The safety reassessment further evaluated the accident management arrangements and emergency plan provisions.

The outcome of the NNR review of the safety reassessment performed by Necsa on the SAFARI-1 facilities addresses in broad aspects the objective as required by the directive.

The review of the SAFARI-1 safety reassessment relating to external events found that:

1) The scope of the safety reassessment was limited to extreme natural external events. The NNR directive required that the safety reassessment must include “flooding, earthquake, other extreme natural phenomena and combinations of external events appropriate to each nuclear installation site” as well as “Other extreme external conditions challenging the specific site”. The safety reassessment therefore falls short of the NNR expectations and requirements with respect to the scope of the external events considered in the safety reassessment. The screening out of certain events from the scope of the safety reassessment has not been adequately justified.

2) In the treatment of a beyond design basis tornado and high winds the size of the missile generated by the tornado that could lead to the postulated damage states is not specified or contemplated. This omission undermines the validity of the presented information and must be considered in an update of the analysis.

In addition to the improvement actions identified by Necsa, the following finding relating to external events should specifically be addressed by the operator:

- Expand the scope of the safety reassessment to include explosions, aircraft crash and toxic gasses and potential combinations of events.

2 DESIGN ISSUES

2.1 NNR’s planned activities

Safety of the Koeberg Power Station

Reactor Safety

Consistent with the concept and principle of defense-in-depth, adequate provisions are in place to mitigate consequences of similar type of events. The Koeberg Nuclear Power Plant located in the Western Cape is designed robustly to withstand potential earthquakes and external flooding events such as tsunamis.

Both the actual structures that form the containment and the engineered safety systems have been designed and built to meet required standards.

The Koeberg Nuclear Power Plant has been designed to withstand an earthquake resulting in peak ground acceleration (pga) of 0.3g at the site and is constructed on a seismic raft as part of the design provisions to withstand the design basis earthquake. The design also considers a tsunami of 4m high and the plant is conservatively located at about 8m above mean sea level. In addition, the Koeberg Nuclear Power Plant has well-established and implemented General Operating Rules including emergency operating procedures in place that include severe accident management guidelines designed to bring the plant to a safe shutdown condition in the event of a severe accident. Based on risk studies additional safety measures have been implemented at Koeberg over the years, such as procedures for loss of ultimate heat sink, passive hydrogen re-combiners, additional electrical power supplies, etc. Koeberg was among the first plants in the world to implement severe accident management guidelines, and to include these in the training of reactor operators. Furthermore, the Koeberg facility is inspected regularly by NNR personnel and emergency drills are evaluated by NNR teams.

The outcome of the reassessment is that the Koeberg plant has been adequately designed, and is maintained and operated to withstand all the external events that were considered in the original design basis. Nothing has been found to warrant curtailing its operation or to question the system of design margins inherent in the current facility.

Spent Fuel Pool Safety

The safety reassessment concluded that the Koeberg Power Plant, including the SFP's, are adequately designed, operated and maintained to withstand all the external events considered in the design basis.

The safety reassessment further determined the minimum system, structures and components (SSCs) and essential instrumentation that are required for the spent fuel pool heat removal by spent fuel pool boiling and coolant make-up to ultimately prevent damage to fuel in the SFPs. The SFP instrumentation was upgraded as a result of the re-racking of the SFPs project in order to comply with the standard adopted (ANSI 57.2). The modifications included the installation of a safety grade alarm system and redundant measurement for SFP temperature. Sources of water for emergency feed water and spent fuel pool make-up were assessed. Proposals for upgrading the plant against beyond design basis events include a SFP level indication system and an alternative spent fuel pool cooling method following a loss of water.

The consequence of the mechanical impact on most of the areas is enveloped by the current design basis accidents and incidents. The sizing of the anti-siphon breakers fitted on the discharge pipework of the SFP cooling systems has been reassessed and found it to meet the design requirements.

Eskom has also implemented a "*Protect Equipment Programme*" that provides monitoring and management controls for work that is required on protected SFP equipment, support systems, or back-up equipment. Furthermore, relevant incident and accident procedures have been updated to include information of SFP time to boil. This information will be displayed in the control rooms.

Review of Safety Standards and Regulatory Practices

In anticipation of the NNR review of the safety reassessments to be performed by the operators, the NNR Task Team followed international developments, reviewed reports from international peers, received training on accident management strategies and site characteristics as it relates to flooding and seismic safety, as well as training on the technologies related to power supply and cooling functions of the respective nuclear installations.

Internal workshops and meetings were held to discuss insights from international reports and to review accident management processes and site characteristics.

The NNR reviewed reports from international peers to draw insights related to:

a. Strengthening of the NNR Safety Standards
b. Technical aspects/measures to be considered in the review of the safety reassessments
c. Strengthening of the NNR Authorisations and Compliance Assurance processes

In preparation of the NNR review of the safety reassessments the NNR reviewed the site characteristics and envelope considered in the design relating to flooding and seismic for both Koeberg NPP and the SAFARI-1 Research Reactor. The NNR further reviewed the:

a. Basis, safety functions, provisions, inter alia, for Station Blackout for the Koeberg and Necsa sites
b. Basis, safety functions, provisions, inter alia, for cooling of the reactor and Necsa facilities for design and beyond design basis

Design Requirements for New Nuclear Installations

In line with international trends, the NNR requires that new nuclear installations should not require the need for urgent large scale evacuation of the public in case of a nuclear emergency. This position has been informed by international goals for new nuclear installations requiring that any offsite releases that could occur should only require limited offsite emergency response and was implemented with the licensing of the Pebble Bed Modular Reactor (PBMR) and has been incorporated in the Regulations on the licensing of sites for new nuclear installations. It is further recognized, given the lack of guidance in performing deterministic safety analysis that the principal safety requirements as provided in the SSRP's have to be complemented by the following safety objectives to give effect to the NNR approach:

a) Prevention should be the focus by designing for fault tolerance through application of good engineering principles.

b) For all accident sequences including extreme external events taken into account in the design basis, there should be only limited offsite effects and no significant onsite doses for workers as far as reasonably practical.

c) Where an exposure occurs, the likelihood should decrease as the potential magnitude increases

d) Accidents which could lead to early or large releases have to be practically eliminated (should be extremely unlikely to occur with high degree of confidence) and has to be considered in the design of the nuclear installation.

e) Any offsite releases that could occur should only require limited offsite emergency response.

f) The design and operating rules of a nuclear installation, where appropriate and consistent with the graded approach, has to cater both for design basis and beyond basis events considering both internal and external events, and the overall assessment has to integrate deterministic and probabilistic elements.

2.2 Schedule for planned activities

The Regulations will be reviewed as part of the subproject of the NNR Self-Assessment on Regulatory Framework to include specific safety objectives for new nuclear installations.

2.3 Assessment of operators activities

Review of Koeberg Safety Reassessment

The review of the Koeberg safety reassessment report has however also found relating to design issues that:

1) The possible risk to the control rooms and reactor safety systems both from a fire as well as an explosion resulting from hydrogen in the generators needs to be analysed.

2) The Koeberg classification system has to be updated to ensure that maintenance and inspection of non-safety related equipment credited in the Emergency Operating Procedures and Severe Accident Management Guidelines are appropriate for the classification.

3) The assessment does not specifically address the reliability of the instrumentation needed for plant condition monitoring and control to withstand beyond design basis environmental conditions.

The above mentioned findings, in addition to the improvement actions identified by Eskom, should be prioritised and addressed by the operator.

Review of SAFARI-1 Safety Reassessment

A number of improvement actions and/or recommendations have been identified without Necsa committing to the implementation thereof. The main improvement findings highlighted in the Necsa report [21] relates to:

a) Plant modifications including provision for an independent shutdown room, additional diverse instrumentation, increasing robustness of confinement building, submersible pumps in the basement, portable generator to operate submersible pumps, re-flooding nozzle, additional shutdown system and increased robustness of fresh fuel vault.
b) Procedures considering need for early warning of external events, as well as short term and long term post external event actions.
c) Identification, suitability and compatibility assessment of all emergency equipment on the Necsa site that could be used at SAFARI-1, Necsa's Emergency Services and the Electrical and Maintenance groups.

Necsa has been instructed to commit to a list of improvement actions to be implemented in the short, medium and long term.

In addition to the improvement actions identified by Necsa, the following findings relating to the design should specifically be addressed by the operator:

1) Compare high wind, tornado and seismic design basis level of hazard for SAFARI-1 with international standards.
   i. Prioritise the improvement actions presented in the safety reassessment report for implementation considering risk and ALARA. A plan for the implementation thereof should be submitted for NNR approval. As a minimum that plan should include improvement actions relating to:An independent core shutdown and monitoring capability.
   ii. Proposal for the design and maintenance basis as well as a specification for accident and emergency management facilities, equipment and measures.
   iii. Measures to improve the robustness of the SAFARI-1 confinement building against beyond design basis seismic, tornado and high wind hazards.

3 SEVERE ACCIDENT MANAGEMENT AND RECOVERY

3.1 NNR's planned activities

Review of Safety Standards and Regulatory Practices

In preparation of the NNR review of the safety reassessments the NNR reviewed the Accident Management strategies, procedures and facilities of both operators (Eskom and Necsa).

The NNR also reviewed its' Safety Standards as it relates to requirements on mitigation of accidents in case of extreme external events and severe accidents. Section 3.8 of the SSRP requires that:

"Where prior safety assessment or operational safety assessments has identified the reasonable possibility of a nuclear accident, accident prevention and mitigation measures based on the principle of defence-in depth and which address accident management procedures including emergency planning, emergency preparedness and emergency response must be established, implemented and maintained. The principle of defence-in-depth must be applied as appropriate."

The SSRP as well as the conditions of authorisation for the Koeberg Nuclear Power Station requires that amongst others that the licensee complies with provisions related to:

- Management and mitigation measures to be taken in response to a severe accident.

- Responsibilities and training of staff for severe accident management.

A review of the SAFARI-1 nuclear authorisation does not contain a similar condition.

Section 4.3.2 of the SSRP requires that “*maintenance and inspection programmes must be implemented to ensure reliability and integrity of installations; equipment and plant having an impact on radiation and nuclear safety are commensurate with the dose limits and risk limits…* ”. It has been identified that non-safety related equipment credited for in the implementation of accident management strategies (SAMG’s) are not necessarily tested or maintained.

3.2 Schedule for planned activities

The nuclear authorisation for SAFARI-1 needs to be revised to include conditions relating to accident management measures.

The respective nuclear authorisations of all the nuclear installations on site need to be revised to include specific provisions relating to testing and maintenance of all equipment included in the respective accident management measures.

3.3 Assessment of operators activities

Review of Koeberg Safety Reassessment

The review of the Koeberg safety reassessment relating to severe accidents and onsite recovery found that:

1) Portable equipment is considered where plant modifications would not be feasible or ALARA and that some of this equipment have already been procured.

The review of the safety reassessment report has however also found that:

2) The Eskom safety reassessment with respect to personnel and people resources focuses on resources from Operations and does not address resource needs from Radiation Protection, Engineering, Maintenance, Testing, etc. especially in the event of multiple facilities being impacted by a common mode failure for external events.

3) The Koeberg classification system has to be updated to ensure that maintenance and inspection of non-safety related equipment credited in the Emergency Operating Procedures and Severe Accident Management Guidelines are appropriate for the classification.

4) Certain strategies or measures proposed such as reactor pit flooding, containment and spent fuel venting strategies and flooding of the seismic vault in the assessment do not consider the current NNR position and correspondence on these issues.

5) The identification and definition of Cliff Edge Management Points is considered acceptable and requires detail and careful consideration. It is however not apparent whether the proposed Cliff Edge Management Points consider the Spent Fuel Pool (SFP) needs.

6) The assessment does not specifically address the reliability of the instrumentation needed for plant condition monitoring and control to withstand beyond design basis environmental conditions.

In addition to the improvement actions identified by Eskom, the following findings relating to severe accident management and recovery should specifically be addressed by the holder:

- Improvements identified for accident measures (equipment and facilities) susceptible to common mode failure due to external events (design basis and beyond design basis), such as earthquake, should be prioritised.
- Improvement actions ensuring reliable power supply to essential accident management equipment for prolonged periods as well as Auxiliary Feedwater (ASG) water supply in case of beyond design basis common mode failure due to external events.

- Expand the resources and facilities needs analysis to include resources needed from Radiation Protection, Engineering, Maintenance and support as well as to consider multiple facilities being impacted by a common mode external event.

Review of Necsa Safety Reassessment

The review of the SAFARI-1 safety reassessment relating to severe accident management and recovery found that:

1) The impact on accident management resources and facilities in case of a common mode failure that impacts multiple facilities on the Necsa site have not been adequately performed or demonstrated.

2) The safety reassessment report does not adequately address the reliability of communication equipment and information flow onsite during extreme external common mode events. The basis and methodology used to determine the adequacy of emergency preparedness and response arrangements are not clear.

In addition to the improvement actions identified by Necsa, the following findings relating to severe accident management and response should specifically be addressed by the operator:

- Systematically assess the robustness of these accident measures against common mode failure due to external events and implement and maintain necessary improvement actions.
- Assess the reliability of communication equipment and information flow on site during extreme common mode failure due to external events and implement necessary improvement actions.

4 NATIONAL ORGANISATIONS

4.1 Review of National Organisations

NNR Self-Assessment

Under the framework of IAEA Regional Project RAF09/38 the National Nuclear Regulator (NNR) and the Directorate of Radiation Control (RADCON) in the Department of Health (DOH), undertook a self-assessment to review the effectiveness of the national legislative and regulatory framework for nuclear and radiation safety.

Following national and organizational training on the IAEA SAT, the Self-Assessment Project was conducted over a period of 8 months and key management and technical staff members participated to evaluate the national regulatory compliance with IAEA standards and international undertakings. The action plans and final report were reviewed by the members of the Joint Coordinating Committee established between the Regulatory Bodies under a Memorandum in respect of monitoring and control of radioactive material or exposure to ionizing radiation.

The scope of the first South African Self-Assessment lifecycle under AFRA Project RAF09/38 on Self-Assessment of Regulatory Infrastructure for Radiation Safety and Networking of Regulatory included the following aspects:

- Legislative and Government Responsibilities
- Responsibilities and Functions of the Regulatory Body
- Organisation of the Regulatory Body
- Authorisation by the Regulatory Body
- Review and Assessment by the Regulatory Body
- Inspection and Enforcement by the Regulatory Body
- Development of Regulations and Guides of the Regulatory Body
- Management System for the Regulatory Body
- Radioactive Waste management and Decommissioning (NNR only)

Three action plans were derived from the SAT, namely a national action plan, a NNR action plan and a RADCON action plan with timescales associated with each of the actions. The recommendations were grouped according to different themes, and 76 actions were incorporated into an action plan, of which 15 are regarded as national actions, which have to be completed within three years. The national actions include the findings for which the appraisal criterion is not met and the joint RADCON-NNR actions. A total of 33 actions were identified for the NNR and 28 for RADCON.

Priority actions have been identified and are being addressed. 42% of the priority actions have been completed with the balance of the priority actions to be completed by March 2014. Included in these priority actions are the review and update of the Regulatory Standards and Practices. The NNR is in the process of revising its Safety Standards and Regulatory Practices. The lessons learnt from Fukushima will be considered in the update of the Safety Standards and Regulatory Practices.

Koeberg review

The NNR issued a directive to Eskom on 10 May 2011 to perform a safety reassessment of Koeberg Nuclear Power Station with respect to external events, both in the design basis and risk analysis, taking into consideration lessons learned from the Fukushima accident. It was required that the safety reassessment be used to identify modifications, measures and technical features to be implemented as necessary to improve safety of the plant.

Eskom was required to submit a project plan by 10 June 2011 to achieve the objectives of the safety reassessment, which was required to be completed by 30 November 2011. Eskom conducted the assessment.

The NNR review and assessment findings were transmitted to Eskom by letter on 28 March 2012 in which it was required that Eskom provide by 30 April 2012 a proposal on the way forward in terms of corrective actions and to address the NNR review comments.

Eskom responded accordingly with a plan in three phases:

- Outstanding studies and analyses
- Response to NNR requirements findings and comments
- Proposed plan for short term improvements.
- Timelines for long term modifications.

The NNR review of this submission will be finalised by 7 June 2012.

Action	**Due Date**
Directive to Eskom	10 May 2011
Project Plan	10 June 2011
Completion of Safety Reassessment	30 November 2011
NNR review findings to Eskom	28 March 2012
Proposed plan on corrective actions	30 April 2012
NNR review of corrective action plan	7 June 2012

4.2 Schedule for planned activities

Continue with the implementation of the respective Self-Assessment Action Plans.

5 EMERGENCY PREPAREDNESS AND POST-ACCIDENT MANAGEMENT

5.1 NNR's planned activities

National Review of emergency preparedness and response arrangements and capabilities

The IAEA Action Plan on Nuclear Safety calls on Member States to conduct a prompt national review and thereafter regular reviews of their emergency preparedness and response arrangements and capabilities, with the IAEA Secretariat providing support and assistance through Emergency Preparedness Review (EPREV) missions. Under the auspices of the FNRBA an assessment of the national emergency preparedness and response arrangements in South Africa has been conducted. The main conclusions relating to nuclear emergencies/accidents can be summarised as follows:

- Although legislative provisions for emergency preparedness are included in the NNR Act and overall in the Disaster Management Act, no specific regulations on nuclear and emergency preparedness and response are in place;
- The legal responsibilities of the Regulatory Body with regard to preparedness and response for a nuclear emergency should be reviewed;
- The need to review the emergency plans at a national level to ensure integration and compatibility of plans from other government agencies and organisations. A national "all hazards" emergency plan for an integrated response to any combination of hazards is in the process of being established;
- The capability to initially treat and follow up on exposed and contaminated patients are not regarded as adequate;
- The Regulatory Body does not act as the national contact point on a 24-hour basis, for receiving / sending emergency notifications of an actual or potential nuclear or radiological emergency;

It is recommended that South Africa should perform a full self-assessment using the EPREV and Self-Assessment questionnaires, and request subsequently an EPREV mission to independently assess the overall (both nuclear and radiological) emergency preparedness and response infrastructure in the country. It will assist in evaluating whether the national emergency preparedness and response programme contains appropriate arrangements for responding to nuclear or radiological emergencies in accordance with IAEA standards, and provide information on best practices from other countries.

Review of Safety Standards and Regulatory Practices

The requirement for Emergency Planning, Preparedness and Response is imposed on holders and applicants of nuclear installation licenses in section 3.8 of the SSRP and further in the NNR requirements documents – *RD-0014: Emergency Preparedness and Response Requirements for Nuclear Installations [18].* The holders of nuclear installation license are required to ensure that the emergency preparedness and response plans are prepared for any action or source that is capable of causing nuclear damage or which could give rise to an emergency requiring intervention. The holder is required to periodically conduct a comprehensive safety analysis of sources of potential exposure to evaluate radiation dose that could be received by workers and the public as well as potential effects.

The NNR regulatory requirements provides for emergency planning, preparedness and response. However, these plans are typically devised not considering an initiating event concurrently affecting multiple facilities, destruction of emergency planning infrastructure due to extreme external events and common mode failures. Severe and combinations of external hazards should be considered in the design basis of accident management measures and emergency planning arrangements.

The NNR has consistently applied controls over urban developments in the 16 km emergency planning zone of Koeberg. This level of control is presently not commonly exercised by regulators elsewhere in the world, and is considered further justified following the Fukushima accident.

5.2 Schedule for planned activities

Perform a full self-assessment using EPREV and IAEA Self-Assessment questionnaires in conjunction with relevant government departments.

The SSRP will be reviewed as part of the subproject of the NNR Self-Assessment on Regulatory Framework to include specific requirements related to the robustness of accident management measures and emergency planning arrangements considering beyond design basis external events.

5.3 Assessment of operators activities

Review of Koeberg Safety Reassessment

The review of the Koeberg safety reassessment related to emergency preparedness and response found that:

1) The safety reassessment report does not adequately address the reliability of communication equipment and information flow onsite and with intervening organisations during common mode failure due to extreme external events.

In addition to the improvement actions identified by Eskom, the following findings relating to emergency preparedness should specifically be addressed by the holder:

- Improvement actions identified for emergency management measures (equipment and facilities) susceptible to common mode failure due to external events (design basis and beyond design basis), such as earthquake, should be prioritised.
- Evaluate the effectiveness of standing offsite arrangements against common mode external events included in the emergency plan. As part the evaluation, special attention should be given to the reliability of communication with the public and other intervening organisations.

Review of Necsa Safety Reassessment

The review of the SAFARI-1 safety reassessment related to emergency preparedness found that:

1) The impact on emergency planning resources and facilities in case of a common mode event that impacts multiple facilities on the Necsa site have not been performed or demonstrated.

2) The safety reassessment report does not adequately address the reliability of communication equipment and information flow with intervening organisations during common mode failure due to extreme external events. The basis and methodology used to determine the adequacy for emergency management and response are not clear.

In addition to the improvement actions identified by Necsa, the following findings relating to emergency preparedness and response should specifically be addressed by the operator:

- Systematically assess the robustness of these emergency management measures against common mode external events and for multiple facilities being impacted and implement and maintain necessary improvement actions.
- Assess the reliability of communication equipment and information flow with intervening organisations during common mode failure due to extreme external events and implement necessary improvement actions.

6 INTERNATIONAL COOPERATION

6.1 National activities

Integrated Nuclear Infrastructure Review

The Department of Energy (DOE) has initiated the process to review the readiness of the country against the 19 nuclear infrastructure issues to embark on the new nuclear build programme. The review is based upon the approach presented in the IAEA Nuclear Energy Series (NES) publications *Milestones* (NG-G-3.1) and *Evaluation* (NG-T-3.2) and assumes a comprehensive assessment of all nuclear infrastructure issues needed in the specific conditions of a country. The NNR has been part of the Integrated Nuclear Infrastructure Review (INIR) review team. Various short comings and gaps linked to the readiness of the country in anticipation of the new nuclear build programme have been identified.

Action Plans are being developed to address the shortcomings identified and in anticipation of the IAEA host Integrated Nuclear Infrastructure Reviews (INIR) mission.

Integrated Regulatory Review Service

The Regulators in South Africa have performed a detailed Self-Assessment in anticipation of hosting an IAEA Integrated Regulatory Review Service.

Multinational Design Evaluation Programme

MDEP is a multinational initiative that was established in 2006 and uses innovative approaches to leverage the resources and knowledge of the national regulatory authorities who are currently undertaking the review of new reactor power plant designs and/or are in the process of constructing of new reactor power plant. Current MDEP members are the Nuclear Regulatory Authorities of the following countries: Canada, China, Finland, France, Japan, India, Korea, Russian Federation, South Africa, the United Kingdom and the United States. The IAEA is also represented.

The stated goals of MDEP is increased knowledge transfer through the exchange of information on regulatory practices used by the member countries in their design reviews and the enhanced ability of regulatory bodies to cooperate in reactor design evaluations, vendor inspections, and construction oversight. During the interim period before the technology for the SA new build is announced the NNR benefit from participating in the thematic working groups and keeps abreast with developments and interpretation of various international regulatory standards and practices.

<u>OSART Missions</u>

At the request of the government of South Africa, an IAEA Operational Safety Review Team (OSART) of international experts visited Koeberg Nuclear Power Plant from 21 August to 8 September 2011. A previous OSART review was undertaken in 1991. The purpose of the mission was to review various operating practices including severe accident management. The OSART team concluded amongst many others that the establishment of the EERT and the External Events Safety Re-assessment project were regarded as areas of good performance. The team further found that Koeberg NPP was the first plant to include severe accidents at shutdown and the mitigation of fission product releases in the fuel buildings in the suite of Severe Accident Management Guidelines (SAMGs).

<u>WANO Reviews</u>

A WANO team, comprised of experienced nuclear professionals from a number of WANO countries, conducted a peer review at the Koeberg Nuclear Power Station in 2011. The purpose of the review was to determine strengths and areas in which improvements could be made in the operation, maintenance, and support of the nuclear unit(s) at the Koeberg Nuclear Power Station. Information was assembled from discussions, interviews, observations of station activities, and reviews of documentation. The WANO team examined safety culture, self-evaluation, organizational effectiveness, operating experience, operations maintenance, engineering support, training and qualification, radiological protection, chemistry, human performance, work management, plant status and configuration control, industrial safety, and equipment performance and condition. As a basis for the review, the team used the WANO Performance Objectives and Criteria, The Objectives and Criteria for Accreditation of Training in the Nuclear Power Industry; these were applied and evaluated in light of the experience of team members and good practices within the industry. Although not officially part of the scope of the review, the team reviewed Eskom's response to the Fukushima event (response to various WANO Significant Operating Event Reports (SOERs) and response to NNRs Directive).

WANO Peer Reviews have also been routinely carried out in the past – most recently in 2004, 2006 and 2008.Eskom has also asked WANO to undertake Technical Support Missions where WANO sends subject experts to Koeberg to provide focussed assistance where it is considered necessary.

INPO Accreditation
Eskom is not a member of INPO (which is just for USA utilities) but has strong links to this organisation, mainly through its membership with WANO (Atlanta). Specifically Koeberg have used INPO to accredit its Operator Training programme which involves routine reviews of the training programme at Koeberg in order to maintain the accreditation.

6.2 Schedule for planned activities

Integrated Nuclear Infrastructure Review

Complete INIR self-assessment and request an IAEA Integrated Nuclear Infrastructure Review mission

Integrated Regulatory Review Service

Requests an IAEA IRRS mission to assess its national regulatory framework following the implementation of the Self-Assessment findings

PART D: SUMMARY TABLE, CONCLUSION AND REFERENCES

1 SUMMARY TABLE

Activity	Part B: Activities by Operator (2)			Part C: Activities by NNR (3)		
	Status (a)	Schedule or Milestone (b)	Conclusion (c)	Status (a)	Schedule or Milestone (b)	Conclusion (c)
Topic 1 – External Events						
Review of Safety standards and Regulatory Practices				Completed	November 2011	Yes
Update of Safety standards and Regulatory Practices				Planned	March 2013	No
Koeberg: Extended scope of safety reassessment	Planned	April 2014	No			
Koeberg: Compilation of additional procedures	Planned	July 2015	No			
SAFARI-1: Extended scope of safety re-assessment	Taken	TBD	No			
Topic 2 Design Issues						
Review of Safety standards and Regulatory Practices				Completed	November 2011	Yes
Update of Safety standards and Regulatory Practices				Planned	March 2013	No
Koeberg: Short-term interventions (Procurement of portable equipment)	On-going	September 2013	No			

Activity	Part B: Activities by Operator (2)			Part C: Activities by NNR (3)		
	Status (a)	Schedule or Milestone (b)	Conclusion (c)	Status (a)	Schedule or Milestone (b)	Conclusion (c)
Koeberg: Short-term interventions (Portable equipment plant modifications)	Planned	May 2017	No			
Koeberg: Long-term interventions (Identification of modification themes)	Planned	September 2012	No			
Koeberg: Long-term interventions (Implementation of modifications)	Planned	2022	No			
SAFARI-1: Modification Strategy and action plan	Planned	June 2012	No			
SAFARI-1: Implementation of Modifications		TBD	No			
Topic 3: Severe Accident Management and Recovery						
Revise SAFARI-1 Nuclear Authorisation to include condition relating to accident management measures				Planned	March 2013	No
Revise Koeberg and SAFARI-1 nuclear authorisations to include conditions relating to testing and maintenance of accident management equipment				Planned	June 2013	No
Koeberg: Short-term interventions (Portable equipment plant modifications)	Planned	May 2017	No			

Activity	**Part B: Activities by Operator (2)**			**Part C: Activities by NNR (3)**		
	Status (a)	Schedule or Milestone (b)	Conclusion (c)	Status (a)	Schedule or Milestone (b)	Conclusion (c)
Koeberg: Long-term interventions (Identification of modification themes)	Planned	September 2012	No			
Koeberg: Compilation of additional procedures	Planned	July 2015	No			
SAFARI-1: Modification Strategy and action plan	Planned	June 2012	No			
Topic 4: National Organisations						
Continue with the implementation of the respective Self-Assessment Priority Action Plans				On-going	March 2015	No
Directive to Operators				Completed	May 2011	Yes
Koeberg Safety Re-assessment	Completed	November 2011	Yes			
SAFARI-1 Safety Re-assessment	Completed	November 2011	Yes			
Review of Koeberg Safety R-assessment				Completed	March 2012	Yes
Review of SAFARI-1 Safety R-assessment				Completed	March 2012	Yes
Topic 5: Emergency Preparedness and Post-Accident Response						
Perform Self-Assessment using EPREV and IAEA Self-Assessment questionnaires				Planned	TBD	No,
Review of Safety standards and Regulatory Practices				Completed	November 2011	Yes

Activity	Part B: Activities by Operator (2)			Part C: Activities by NNR (3)		
	Status (a)	Schedule or Milestone (b)	Conclusion (c)	Status (a)	Schedule or Milestone (b)	Conclusion (c)
Update of Safety standards and Regulatory Practices				Planned	March 2014	No
Topic 6: International Cooperation						
Complete INIR self-assessment				On-going	June 2012	Yes
Request IAEA INIR mission				Planned		No
Requests IAEA IRRS mission national Regulatory infrastructure				Planned	TBD	No

2 CONCLUSION

The safety reassessments undertaken by South Africa operating organisations have not raised any significant findings, either on the safety of Koeberg NPP or the SAFARI-1 research reactor.

In the case of Koeberg NPP the reassessments indicate that the plant conforms to the design basis which addresses external events with a return period of at least 10,000 years. Eskom has implemented modifications and accident procedures at Koeberg NPP to prevent or mitigate the consequences of severe accidents that are beyond the design basis, thereby largely addressing one of the main post Fukushima actions.

Nevertheless, the safety reassessments reports from the operators highlighted certain vulnerabilities against extreme external events and a combination of events. Various proposals have been made to make the respective facilities and designs more robust to withstand external events not considered in the design and that are beyond the design basis. The NNR instructed the respective operators to evaluate the improvement proposals made in line with its principal nuclear and radiation safety requirements as stipulated in the national Safety Standards and Regulatory Practices This includes the risk and the principle of ALARA. The NNR will direct them to implement improvement actions as deemed necessary.

Similar initiatives to ensure that safety reassessments are performed in light of the Fukushima event are being carried out by international regulators and organizations such as the IAEA. The NNR will keep abreast of and will participate in international developments in this regard. The IAEA Action Plan on Nuclear Safety has been reviewed to establish the basis for NNR response actions to the Fukushima accident.

With regards the nuclear regulatory framework in South Africa, the NNR has consistently imposed risk criteria on the nuclear industry. The NNR has been a leader in this approach, which, following the Fukushima accident, is receiving more attention worldwide. The NNR has also consistently applied strict controls over urban developments within the 16 km emergency planning zone for Koeberg NPP.

The Fukushima Daiichi accident will continue to provide an impetus for evaluating safe operations, design considerations, and raising the level of emergency preparedness of NPPs in an effort to ensure the robustness of plant systems against extreme external events.

3 REFERENCES

[1] Report of Japanese Government to IAEA Ministerial Conference on Nuclear Safety - Accident at TEPCO's Fukushima Nuclear Power Stations

[2] IAEA International fact finding expert mission of the nuclear accident following the Great East Japan earthquake and tsunami

[3] USNRC: The near-term task force review of insights from the Fukushima-Daiichi accident

[4] ONR: Japanese earthquake and tsunami: Implications for the UK Nuclear Industry – Interim and Final Reports

[5] MIT: Technical Lessons Learned from the Fukushima-Daiichi Accident and Possible Corrective Actions for the Nuclear Industry: An Initial Evaluation

[6] INPO 11-005 November 2011 Special Report on the Nuclear Accident at the Fukushima-Daiichi Nuclear Power Station

[7] National Nuclear Regulator Act, "Act No. 47 of 1999: National Nuclear Regulator Act, 1999", published in Republic of South Africa Government Gazette, Vol. 414, No. 20760, 23. December 1999

[8] NNR Directive, k10000585N, dated 10 May 2011

[9] Eskom letter, K-20118-E, Updated Strategy and Project Plan

[10] NNR letter, k20118N, UPDATED PLAN TO ADDRESS NNR DIRECTIVE FOR SAFETY REASSESSMENT OF THE KOEBERG SITE, dated 3 August 2011

[11] Eskom letter, K-20265, Submittal of EERT-11-013, Rev 1, dated 21 December 2011

[12] Eskom letter, K-20298-E, dated 3 February 2012

[13] NNR Directive, NIL02B0204, dated 10 May 2011

[14] NNR letter, NIL02B0246, dated 10 August 2011

[15] LD-SAFARI2011-REP-0025, Safety Reassessment Report for the SAFARI-1 Reactor under Severe External Events, dated 29 November 2011

[16] Regulations in Terms Of Section 36, Read With Section 47 Of The National Nuclear Regulator Act, 1999 (Act No. 47 Of 1999), On Safety Standards And Regulatory Practices (Published in Government Gazette 28755 April 2006)

[17] RD-0024: Requirements on Risk Assessment and Compliance with Principal Safety Criteria for Nuclear Installations.

[18] RD-0014: Emergency Preparedness and Response Requirements for Nuclear Installations

[19] RD-0034: Quality and Safety Management Requirements for Nuclear Installations

[20] TR-KP-12-001, Review of the Koeberg Fukushima Safety Reassessment Report, NNR, March 2012

[21] TR-NTWP-12-001, Review of the Necsa Fukushima Safety Reassessment Report, NNR, March 2012