IMPLEMENTATION OF THE INTEGRATED PLANNING CONCEPT TO STRENGTHEN INDONESIAN RADIATION EMERGENCY RESPONSE CAPABILITIES

A Thesis

by

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ABSTRACT

Nuclear power has been included in Indonesian national plan as an alternative solution for electricity production. However, Indonesia lies within the Pacific Ring of Fire with around 129 active volcanoes along its region. In addition, the Indonesian archipelago is formed by three major tectonic plates that continuously collide and move: the Eurasian Plate, the Pacific Plate, and the Indo-Oceanic-Australian Plate. Consequently, the entire Indonesian archipelago is relatively unstable due to high volcanic and seismic activities. In anticipation of the development of a nuclear power program and to ensure the safety of the current practices, the Indonesian government has the responsibility to provide an integrated conventional and nuclear/radiological emergency response plan. This plan is the basis to conduct response activities and the core of a national response framework.

In this research, the current capability of the Indonesian government to respond a nuclear/radiological emergency is investigated. The result shows that appropriate response agencies as well as the legal framework governing emergencies have been formed. However, neither a conventional nor a nuclear/radiological emergency response plan has been established. To improve the current emergency system, the IAEA's graded approach methodology for an integrated emergency planning is partially implemented. This graded methodology allows for a thorough evaluation, and ultimately strengthening Indonesian national response capabilities, correcting the defects in the current system, and building an integrated emergency response plan.

For my beloved grandma, mak Gadih

For mama, papa, Fera, and Ryan

Without you all, I will never go this far. Your everlasting love, prayers, support and encouragement have been my strength and true inspiration

For my beloved nephew, Farrel

One day you will go beyond my mileage

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NOMENCLATURE

EPR	Emergency Preparedness and Response
LDMA	Local Disaster Management Agency
IAEA	International Atomic Energy Agency
NBDM	National Board for Disaster Management
NCA	National Coordinating Authority
NERA	National Energy Regulatory Agency
NEPR	Nuclear Emergency Preparedness and Response
NNEA	National Nuclear Energy Agency
NR-EPR	Nuclear/Radiological Emergency Preparedness and Response
NRF	National Response Framework
SSNI	Safety and Security of Nuclear Installations
PAZ	Precautionary Action Zones
UPZ	Urgent Protective Action Planning Zone

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1. INTRODUCTION

1.1. Background

The Republic of Indonesia is an archipelagic country in the southeastern region of Asia and is comprised of approximately 17,508 islands, 6000 of which are inhabited (Figure 1). The country lies along the equator between the Indian Ocean and the Pacific Ocean and shares land borders with Malaysia, Papua New Guinea, and East Timor. Additionally, it shares maritime borders with Australia, Singapore, Thailand, Philippines, and Vietnam. Indonesian territory encompasses the land area of about 1.9 million square kilometers (approximately three times the size of Texas). Based on census in 2013, its population reached 249 million people, making Indonesia the 4th largest populated country in the world.

Despite the number of islands, the majority of Indonesians reside in Sumatera, Java, Borneo, Sulawesi, and Papua islands. Java is the most populated island, where the country's capital and most industrial centers are located. Consequently, as the population grows, the energy consumption also increases. Current energy needs are primarily met via fossil fuel, along with natural gas. However, domestic natural resources are limited. It is projected that the national production of fossil fuel will only be able to supply the domestic demand for approximately 23 - 62 years, while natural gas production is predicted to last for approximately 146 years (Republic of Indonesia, 2006a). This condition has forced the Indonesian government to find an alternative solution for energy production to reduce the dependence on current resources.

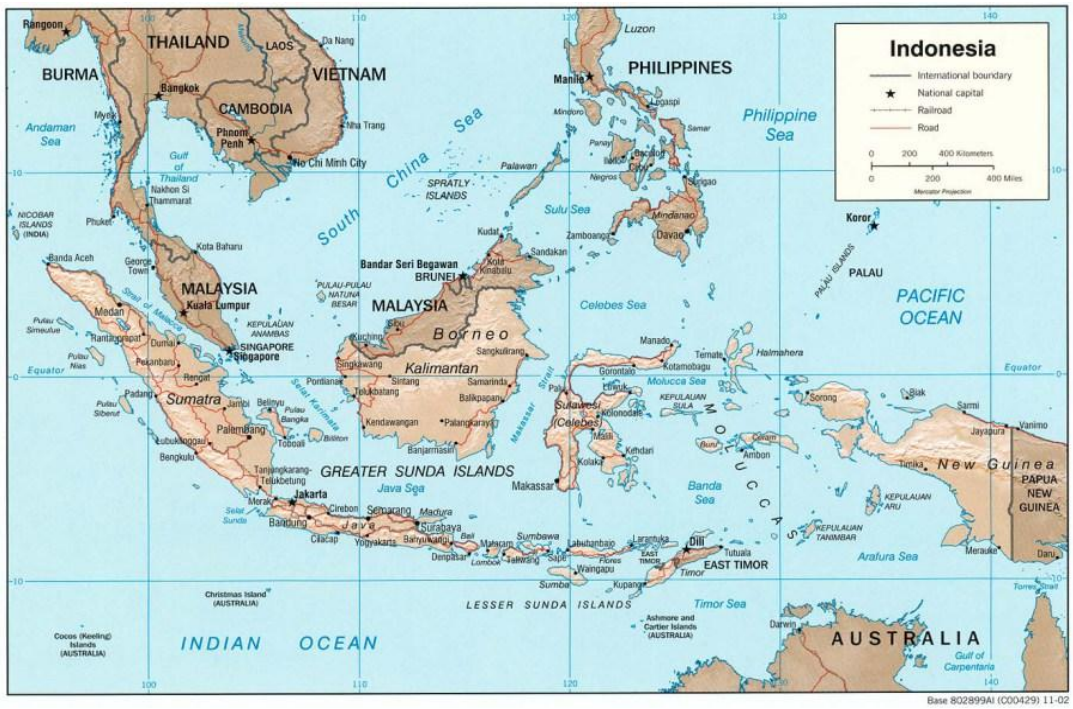

Figure 1. The map of Indonesian archipelago; Sumatra, Java, Borneo, Sulawesi, and Papua are the major islands (Perry-Castaneda Library Map Collection, 2014).

In 2006, the president of the Republic of Indonesia established the Presidential Regulation on National Energy Policy (Republic of Indonesia, 2006b). The regulation is intended to secure domestic energy resources by reducing the use of fossil fuel and accelerating the development and the use of new and renewable energy by 2025. Among the considered alternative energy resources stated by the president are biomass, water, solar, wind, and nuclear. In 2007, the Energy Law was established to provide the legal basis for the implementation of the National Energy Policy. One important feature of this law is the establishment of the National Energy Council (NEC), which would be responsible for designing and drafting the policies, taking the necessary actions to

conserve national energy, and controlling the overall process of energy conservation (Republic of Indonesia, 2007a).

The nuclear power program has been a long debated issue in Indonesia. The research and development on the application of nuclear energy was started in the 1960's, and since then, the government's nuclear research center has pursued the development of a nuclear power plant. However, no significant progress has been made. As part of the nuclear power project, site evaluations were conducted, and the Muria Peninsula in Central Java was later chosen as the location for the power plant. Its location on Java Island is considered strategic due to the fact that the highest energy demand comes from this area. The site study was completed in 1996, but the project was discontinued for various reasons. One of the major reasons was the objection to nuclear power from the residents of Muria Peninsula and its vicinity. Regardless of the benefits of nuclear power, the residents were more concerned about the risks of an accident that could cause the release of radioactive material.

The public's concern about the safety of operating a nuclear power plant in Indonesia arose largely due to the country's long history of natural disasters. Indonesia's location on the Pacific Ring of Fire makes the volcanic activities relatively high; around 129 out of 500 volcanoes in Indonesia are still active, and volcanic eruptions occur on a frequent basis (see Figure 2). In addition, Indonesian archipelago is formed by three major tectonic plates that continuously collide and move - the Eurasian Plate, the Pacific Plate, and the Indo-Oceanic-Australian Plate- making the entire Indonesian archipelago relatively unstable. Earthquakes happen frequently with various magnitudes, where the

number of recorded events can exceed 1000 earthquakes per year (Goltenboth and Erdelen, 2006).

Figure 2. This picture shows the major volcanoes in Indonesia (Major volcanoes of Indonesia, 2014)**.**

Despite these setbacks and public concerns, the Indonesian government is still pursuing a nuclear power program. The International Atomic Energy Agency (IAEA) recommends that every country considering a nuclear power program develop and establish a nuclear/radiological emergency preparedness and response (NR-EPR) plan before any plant is built (IAEA, 2012). In this research, the Indonesian radiation emergency preparedness and response system will be investigated; the availability,

applicability, effectiveness, and weaknesses of the current Indonesian NR-EPR system will be explored. Subsequently, improvements will be prescribed by using the IAEA's graded approach methodology. The IAEA's standards and guidance and the United States National Response Framework (NRF) will be used as the main reference.

This research is not intended to create a national NR-EPR plan for Indonesia, but rather possibly serve as the roadmap to create the EPR plan and as a basis for reformation. It is hoped that this research will provide valuable guidance in the development of an effective NR-EPR plan that will strengthen Indonesian national response capabilities.

1.2. Literature Review

The essence of an EPR plan is to support the safe operation of the nuclear power plant and thus protect people, society, and the environment from the potential hazards associated with its operation (IAEA, 2012). In the case of Indonesia, developing the EPR plan is vital not only from nuclear power safety considerations, but also the safety and security of current practices. Aside from research reactors, radioactive materials are widely used for research, medical, and industrial purposes. Also, the stakeholders are located throughout the archipelago, which raises the concern of illicit trafficking because of the daily transport of radioactive material.

Emergency management generally consists of two phases: preparedness and response (IAEA, 2002). An emergency preparedness program is intended to ensure the availability of methods, procedures, training, facilities and equipment, as well as inter-

agency coordination framework prior to the emergency situation. Meanwhile, the emergency response is intended to provide adequate protection from radiation exposure to the public, property, and the environment following an emergency situation. In addition, part of the response is to mitigate the consequences of the event.

The main elements for an EPR based on the IAEA safety standards are presented below; requirements for preparedness and response phases apply for each element (IAEA, 2002).

- Basic responsibilities
- Assessment of threats
- Establishing emergency management and operations
- Identifying, notifying and activating
- Taking mitigatory actions
- Taking urgent protective actions
- Providing information and issuing instructions and warnings to the public
- Protecting emergency workers
- Assessing the initial phase
- Managing the medical response
- Keeping the public informed
- Taking agricultural countermeasures, countermeasures against ingestion and longer term protective actions
- Mitigating the non-radiological consequences of the radiation emergency and the response
- Conducting recovery operations
- Requirements for infrastructure.

To assist a country developing its NR-EPR system and seeking to comply with the safety standards, the IAEA introduced the integrated planning concept which covers all elements and variables of emergency events in one management framework. In this concept, all hazards are addressed in a general national emergency plan and specific NR-EPR plans are established based on the general plan. Figure 3 shows the integrated

planning concept; it illustrates the structure of the general emergency plans and the associate plans in the lower levels.

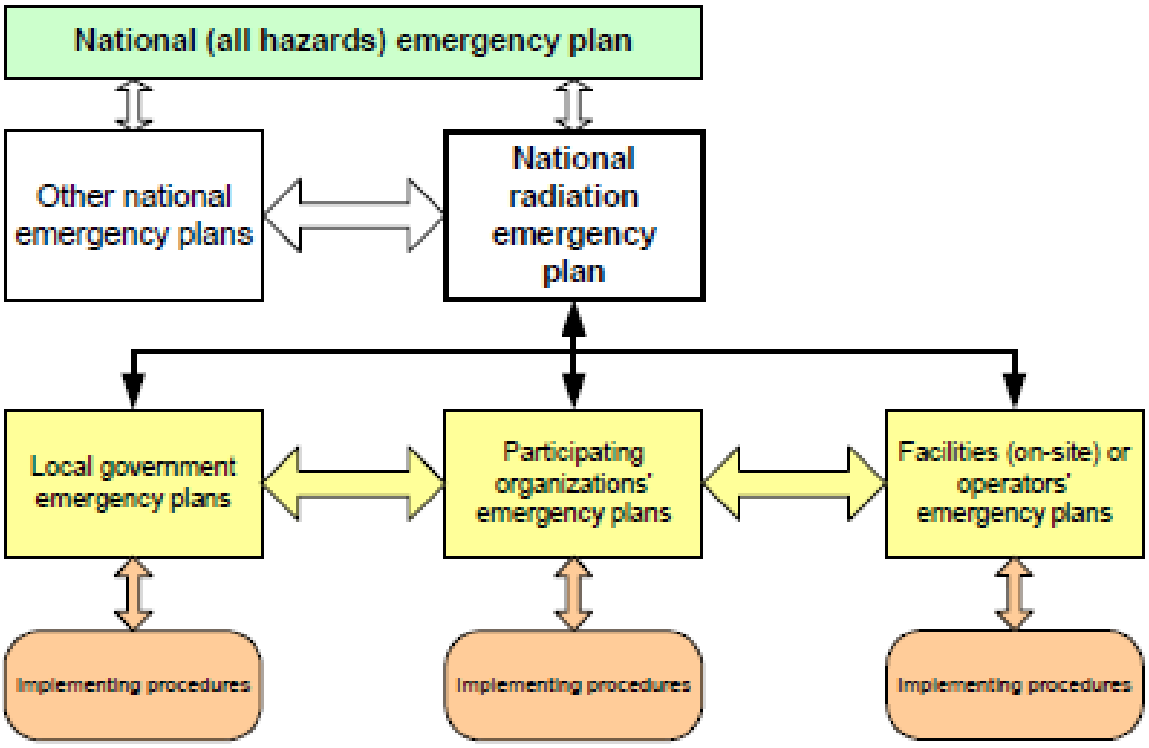

Figure 3. The illustration of an integrated planning concept based on the IAEA-EPR Method 2003 (IAEA, 2003).

The integrated planning concept is developed using a graded approach methodology. The methodology consists of several tasks which need to be performed gradually to establish an effective response framework. For this research, implementation of the tasks is grouped into two phases. Phase 1 consist of tasks 1 – 5, and phase 2 covers task 6 – 10. Performing phase 1 will allow for identification of the weaknesses in emergency response capabilities and enhancing the interim capabilities.

To fully develop emergency response capabilities, all tasks from the two phases need to be completed. In this research, only the tasks in phase 1 will be implemented. The overall tasks, based on the IAEA EPR-Method 2003 (IAEA, 2003), are listed below.

Task 1. review national policy

Task 2. perform threat assessment

Task 3. develop planning basis

Task 4. develop concept of operations and allocate responsibilities

Task 5. develop interim capabilities

Task 6. write national radiation emergency plan

Task 7. present national radiation emergency plan

Task 8. implement detailed plans

Task 9. test the capability

Task 10. establish ongoing quality assurance and maintenance

2. CURRENT STATUS ON NUCLEAR AND RADIOLOGICAL EMERGENCY RESPONSE SYSTEM IN INDONESIA

2.1. Emergency Management

Radiation emergency management in Indonesia lies under the general disaster management framework. The framework is designed such that the main responsibility for disaster management attaches to the lowest possible government level to ensure the effectiveness of disaster management. Therefore, the disaster management agency is established in three levels of government: national, provincial, and municipal/district level.

In the event of nuclear or radiological emergency, the Indonesian disaster management agency shall cooperate with the other participating organizations, which consist of government entities possessing the capability to enact an appropriate emergency response operation. The roles of the main agencies are discussed in the following paragraphs.

2.1.1. National Board for Disaster Management (NBDM)

The NBDM is a non-ministerial government agency chaired by a minister-level official. It formulates policies in disaster management, and manages the evacuation of people in a proper and efficient manner. In addition, it is also responsible for conducting planned, integrated, and comprehensive coordination in the event of an emergency among all relevant disaster management stakeholders at the national level. Similar

responsibilities are carried out by the Local Disaster Management Agencies (LDMA), which work to ensure the disaster management at the provincial and municipal/district level, unless the scale of he disaster exceeds the capabilities of the local agencies and require the involvement of the NBDM.

To carry out its disaster management duties, the NBDM cooperates with other relevant institutions. These institutions support various specific functions such as search and rescue, evacuation, mapping, providing hydro-meteorological data, research, and other related functions. In an emergency situation, the NBDM takes the lead role to direct the response operation.

2.1.2. National Nuclear Energy Agency (NNEA)

The NNEA is a non-ministerial government agency with the responsibility to conduct research and development on the application of nuclear energy in Indonesia. The research facilities include research reactors, irradiation facilities, and radioactive waste management centers. Additionally, it manages the laboratories' radiation metrology, safety and health control, and environmental monitoring. Most NNEA facilities are centralized in the Science and Technology Research Center in the Serpong area which is located about 25 miles away from the Indonesian capital city of Jakarta. Other facilities are located in Bandung (West Java) and Jogjakarta (DI. Jogjakarta).

NNEA's resources are considered as the only assets that have the capacity to perform radiological assessment and monitoring. Thus, in terms of nuclear and radiological emergency management, the NNEA is appointed to be the radiological

assessor which is responsible to carry out radiation survey and monitoring, and dose assessment.

2.1.3. Nuclear Energy Regulatory Agency (NERA)

The NERA was established as an independent regulatory body in 1997. Prior to that time, the regulatory control function was carried out by the NNEA, which also served as the stakeholder in addition to being the regulator. Considering the potential conflict of interest, the responsibilities for promoting the utilization of nuclear energy and conducting regulatory functions were assigned to two different agencies.

As mandated by the applicable law, NERA bears the responsibilities to ensure the safe practice of nuclear energy and control of the utilization of nuclear energy in Indonesia. It works to identify and assess the regulatory needs, establish the relevant regulations, issue the licenses, and conduct inspections of the facilities. In terms of a nuclear and radiological emergency system, NERA has the responsibility of evaluating the NR-EPR plans proposed by the stakeholders. In an emergency situation, NERA serves as a consultant to provide technical advice to the emergency responders, as well as supervising emergency response actions. Moreover, it takes the leading role to search, recover, and secure orphan sources as well as in incidents where there is a radioactive release and contamination from other countries.

As the national coordinating authority (NCA) for nuclear and radiological emergency, NERA is responsible for receiving and disseminating information regarding any nuclear or radiological incident inside or outside of Indonesia. To support this

function, NERA established the National Warning Point (NWP), National Competent Authority Domestic (NCA-D), and the National Competent Authority Abroad (NCA-A) within in its organizational structure.

2.1.4. National Army - Directorate of Nuclear, Biology, and Chemistry (DNBC)

Even in cases where an emergency is due to the civilian practice of nuclear energy and radiation, the DNBC of the National Army will take part in the management of a nuclear and radiological emergency. If such a situation occurs and affects the area outside of the facility, the DNBC has the responsibility of carrying out contamination monitoring and decontamination of the people and the environment in the affected area.

2.2. Regulatory Framework

In general, the arrangements for disaster management in Indonesia are established in the form of regulations. Indonesian legislation adopts a hierarchy system where the general provisions are stipulated in higher level regulations and the detail provisions are stipulated in the lower level regulations. The system does not allow lower-level regulations to contain provisions which are not previously stipulated in higher-level regulations. The hierarchy system is shown in Figure 4.

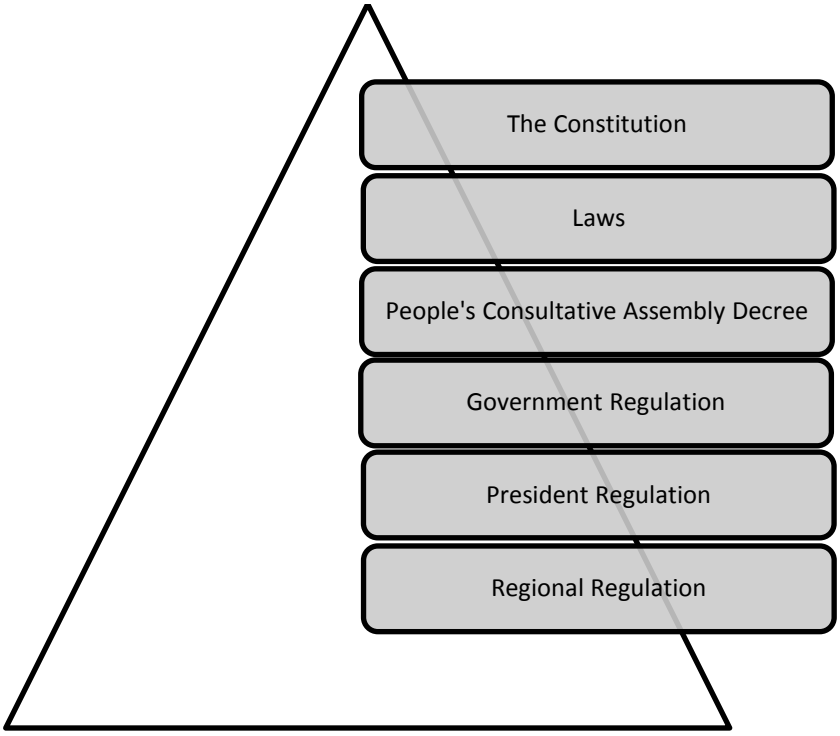

Figure 4. This figure shows the hierarchy of Indonesian legal system based on the Law Making Procedure No. 11 Year 2012. On the top level is the Constitution as the highest legal basis in Indonesia. From top to the bottom, the regulations become more specific and detail.

The following regulations provide the essential legal basis for disaster management in Indonesia. Some of these specifically regulate nuclear and radiological related matters. The provisions are intended to govern a broad range of emergency management including nuclear and radiological emergencies.

2.2.1. Disaster Management Law

The Disaster Management (DM) Law serves as the basic legislation for overall emergency management in Indonesia. It specifies the definitions related with disaster management and stipulates the responsibilities of central and local governments in the

event of a disaster. The law mandates the establishment of a disaster management agency at the national, provincial, and municipal/district levels in addition to assigning agency roles and responsibilities at every level.

Additionally, the DM Law contains the provisions governing the following matters: the rights and obligations of citizens in the event of a disaster, the involvement of private and international organizations, disaster countermeasures, financial arrangement and aid management, government responsibilities in monitoring the implementation of disaster management, resolution of conflict, and criminal penalties. As commonly applied in the Indonesian legal system, the DM Law only regulates the general provisions. The details are specified separately in lower level regulations.

2.2.2. Nuclear Energy Law

The Nuclear Energy (NE) Law is the legal basis for the utilization of nuclear energy in Indonesia. Based on this law, nuclear energy is defined to cover both the energy released from atomic transformation in fissile material as well as the ionizing radiation from radioactive material. The law mandated the establishment of NNEA and NERA as the agencies responsible for promoting and regulating the utilization of nuclear energy in Indonesia. In addition, it contains provisions governing the safe use of nuclear energy, including the arrangement for transport of radioactive material and management of radioactive waste. This law does not specifically address a particular provision on emergency management but it rather stipulates the basic requirement for safety with an inherent obligation to further provide an arrangement for an emergency management.

2.2.3. Government Regulation on the Conduct of Disaster Management

This regulation details the concept and operation of disaster management in the DM Law. Its provisions cover broad aspects of DM, from the technical requirements to financial arrangements. This regulation defines that the DM consists of three phases: pre-disaster, emergency response, and post-disaster. The responsibilities of disaster management agencies in every level during these three phases are also specified. This responsibility includes the establishment of a DM plan in every level. Based on this regulation, the DM plan contains the program and budget for performing disaster management.

2.2.4. Government Regulation on the Safety of Ionizing Radiation and the Security of Radioactive Material

This regulation consists of detailed safety requirements for the utilization of radioactive material and the facilities, including the requirement for establishing a radiological emergency plan for pertinent facilities. The format and detailed requirements of the emergency plan are stipulated, however these requirements are imposed to the licensees. The regulation does not stipulate the arrangement for response to the escalation of emergency outside of the facility.

2.2.5. Government Regulation on the Safety and Security of Nuclear Installations

This regulation stipulates the general provisions for NR-EPR. It requires that a NR-EPR plan should be established, not only at the facility level, but also at the

provincial and national levels, as an integral part of the national/provincial program for disaster management.

2.2.6. Presidential Regulation on the Ratification of the Convention on Early Notification of a Nuclear Accident and Presidential Regulation on the Ratification of the Convention on the Assistance in the Case of a Nuclear Accident or Radiological Emergency

Following the nuclear power plant accident in Chernobyl, the IAEA adopted the Convention on Early Notification of a Nuclear Accident in 1986. The Convention is intended to provide a system for notification on a nuclear accident, which could involve a significant radioactive release to other countries. In this system, the country where the facility is located has to notify the IAEA and the affected countries regarding the time, location, radioactive release, and other significant data about the accident (IAEA, 2014a). To provide assistance and support to the country where a radiological emergency has occurred, the IAEA adopted the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency as the basis for an international framework for response (IAEA, 2014b).

Indonesia became a party to both of the conventions on September 1986 and ratified them in 1996. The presidential regulations endorsed the provisions in the conventions into Indonesian national legal system, and it became the legal basis for imposing the convention's specific requirements to the stakeholders in Indonesia.

2.2.7. NBDM Chairman Regulations

NBDM Chairman Regulations stipulate detailed provisions on conventional emergency management to complement the DM Law and the pertinent government regulations. These regulations govern various aspects of emergency management such as the emergency command system, disaster risk assessment, establishment of the command center, management of disaster data and information.

2.2.8. NERA Chairman Regulations

Complimentary requirements on radiological and nuclear emergencies are established through the NERA chairman regulations. Based on the chairman regulations, the NERA establishes an emergency response force to supervise the on-site and off-site operations and to coordinate the response in particular cases. The response force is in charge of the emergency response operation in the case of the recovery of an orphan source, nuclear satellite re-entry, nuclear or radiological dispersal device explosion, radiological trans-boundary release, and the recovery of nuclear powered ship or sub-marine (Republic of Indonesia, 2007b).

In addition, the NERA chairman regulation requires the licensees to establish a NR-EPR plan for their facilities (Republic of Indonesia, 2010). The regulation also contains the provisions on the preparedness program and requirement for response operations, threat categorization, the establishment of the emergency zones, and guidance dose levels for the emergency worker.

2.3. Radiation Emergency Management

Based on the applicable regulations, all nuclear and radiation facilities are required to provide the necessary resources to support the management of a radiation incident on their site. This includes the establishment of an emergency response organization, plans and procedures, specialized equipment, required team member skills, and scheduled training and drills for emergency personnel. The regulations also require that the facilities report to the NERA when there are increases in the range, scope, and complexity of the emergency situation and if an off-site response is needed.

Further, the Government Regulation on the Safety and Security of Nuclear Installations (SSNI) mandated the LDMA or NBDM to manage the local or national emergency response operation. Once a local or national radiation emergency is declared, the SSNI requires that the emergency response operation is carried out based on the local or national NR-EPR plan. The declaration of local or national emergency is conducted based on the following criteria (Republic of Indonesia, 2012):

a. Local emergency
    1. A dose rate of 5 μSv hr^{-1} or more measured for at least 10 minutes at the boundary of the facility; or
    2. Airborne activity concentration equivalent to the dose rate of 5μSv hr^{-1} at the boundary of the facility.
b. National emergency
    1. A dose rate of 500 μSv hr^{-1} or more measured for at least 10 minutes at the boundary of the facility; or

2. Airborne activity concentration equivalent to the dose rate of 500 μSv hr^{-1} at the boundary of the facility.

2.4. Current National Capacity in Nuclear and Radiological Emergency Response

A national nuclear and radiological crisis center has been established at NERA headquarter in Jakarta. In the event of national nuclear or radiological emergency, the national crisis center can only be activated by the president. All operations of national emergency management will be coordinated and directed from this center by the head of NBDM with assistance from the representatives of every element in the ICS. The crisis center is equipped with a meeting room, communications room, and radiological data monitoring system. Its current operation is managed by the NERA, which also uses the center to perform emergency training and table top exercises.

In addition to the crisis center, NERA has its own resources to perform emergency response operations. These resources include emergency responders, facilities, and equipment. The emergency responders are nuclear and radiological safety inspectors, which have been trained in nuclear/radiological response. A ground-based vehicle for search and recovery is also available, as well as detection and decontamination equipment.

NNEA also has several assets to support an emergency response. These include technical personnel for laboratory dose assessment, environmental sampling, analysis and laboratory facilities. The main laboratory currently is employed for cytogenetics-based biodosimetry, *in vivo* and *in vitro* bioassay, and internal dose assessment.

Moreover, NNEA is capable of providing simple atmospheric dispersion modelling and dose predictions. The meteorological data for this purpose is supplied by the National Agency for Meteorology, Climatology, and Geophysics.

3. ISSUES AND CHALLENGES

Most of the IAEA recommendations for developing an effective EPR system have been established in Indonesian. At present, Indonesia has appointed the national coordinating authority (NCA) to promote the integration of NR-EPR into the conventional EPR system. The IAEA encourages the establishment of an NCA prior to integration of the country's response capabilities, because its role is very important for the integration process (IAEA, 2003). Additionally, most of the IAEA's recommendations for the NR-EPR management have been adopted in the Indonesian legal system. Current regulations enforce the IAEA's basic requirements regarding the allocation of NR-EPR responsibilities and classification of radiation hazards. The IAEA's functional requirements regarding the necessary response actions, even though it has not been fully adopted, have also been stipulated in the regulations.

With all the supporting infrastructures in place, Indonesia should have been able to establish a comprehensive and integrated EPR system. In fact, the progress of implementing the system is slow. The first indicator is the absence of the national NR-EPR plan. The NBDM is mandated by the law to establish a national NR-EPR plan as an integral part of the national emergency plan. After several years, there is no progress in creating the plan. The current Indonesian national emergency plan, which is commonly known as Disaster Management (DM) plan, still focuses on the natural hazards and prioritizes the emergency response program in these areas. Another indicator is the establishment of the national emergency response organization. This organization

includes several government agencies having functions in emergency management. The formation of this organization is intended to perform and support the emergency response actions at the national level. Having this emergency response organization would be strategic considering the current application of nuclear energy in Indonesia and the future plan for the NPP. However, it has not been legally established even though its formation was initiated in 2007.

A conclusion about the current Indonesian EPR system can be drawn from these two indicators. First, there is an internal issue related with the inter-agency coordination. Developing a national NR-EPR plan and establishing a multi-agency organization requires strong cooperation and coordination. Even though it has the responsibility to establish the national NR-EPR plan, the NDBM cannot assign any agencies to be involved without consulting the pertinent agencies. The same rule applies for the formation of the national response organization. Every agency must acknowledge and support their involvement in the overall emergency management plan.

At this point, the function of the NCA is crucial. It takes the active role in the coordination process; it supervises and ensures that the responsibilities of all agencies engaged in the NR-EPR system are assigned properly. The NCA helps the NBDM in the coordination process and accomplishing the mandate for the NR-EPR plan, as well establishing the response organization. However, the NCA's performance is not yet optimal. The NERA, as the NCA, has not been able to coordinate properly with the NBDM and the other agencies. When coordination is not effective, it is inevitable that the development of integrated EPR system would be affected.

To resolve the coordination issue, establishing a legally binding agreement between the NBDM and NERA as the main agencies will be beneficial. This agreement will be the platform of coordination between the two agencies. To be effective, the agreement should contain detailed descriptions of the agencies' responsibilities in developing the integrated EPR system. Once the agreement is formed, both agencies should start to identify the other national organizations which will have roles in radiation emergency response and subsequently involve those agencies so that their responsibilities in emergency response can be defined.

The consolidation between the NBDM and the NERA will undoubtedly foster the integration of the conventional and NR-EPR systems. However, there are challenges in the development of the system. First, the NBDM main program is currently focused on natural disasters which frequently occur in Indonesia. Additional duties in regards to radiation emergencies will require more resources which might not readily be available. For example, the NBDM will need qualified human resources having knowledge in radiation emergency response in its organizational structure. It will also need financial resources to support the necessary infrastructure for the NR-EPR. Second, Indonesia does not have a general emergency management framework. The DM plan as the national reference for of all emergency management plans is not a response framework, but rather contains the government program for conducting disaster risk reduction activities, emergency response and recovery. Consequently, the NR-EPR plan must be explicit in describing the arrangements for radiation emergency response.

There are strategies to address the aforementioned challenges. For the first step, the NBDM has to include the program for developing the national NR-EPR in the DM plan. All radiation hazards associated with the application of nuclear energy have to be identified and incorporated into the DM plan. The NERA should provide the necessary data and information for this purpose. The hazard descriptions do not have to be detailed, but sufficient enough for the NDBM to propose the program. In the program, the NDBM should address the need for human resources and the necessary infrastructure and budgeting. Since the current DM Plan was established in 2010, it will be updated in 2014 because it is effective for a period of five years. During this time, the NBDM and the NERA can prepare for the NR-EPR plan with the assumption that a legal agreement has been made to facilitate the coordination between the two agencies.

Considering the detail required for the NR-EPR plan, it must be planned and drafted carefully. Therefore, the implementation of the IAEA's graded approach methodology for creating a NR-EPR plan will be useful. This metholodogy is designed to be modular, dynamic, and can only be performed with full involvement and cooperation of all relevant response agencies (IAEA, 2003). Section 4 of this thesis will discuss in more detail the implementation of the graded approach methodology, with the emphasis on the first five tasks of the methodology.

4. INTEGRATED EMERGENCY PREPAREDNESS AND RESPONSE SYSTEM

In this section, phase 1 which consists of the first five tasks of the graded approach methodology will be discussed. These tasks review the existing national NR-EPR capabilities, identify the elements which need to be improved, and collect other pertinent information which are important for drafting the plan. The outcome of this process will be the main elements which are necessary in developing a national NR-EPR plan.

4.1. Task 1: Review National Policy

Reviewing the national policy is an essential step in the integration of the EPR system. The purpose of this task is to ensure the availability of a legal framework for establishing a national NR-EPR plan and to identify the needs for revising the existing laws (IAEA, 2003). During this process, the provisions for emergency management on both conventional and NR-EPR regulations have to be taken into account. This is aimed to ensure compliance with the regulations and avoid any legal conflicts in the EPR plan.

The applicable emergency regulatory framework in Indonesia is described in section 2 of this thesis. Based on that description, it can be concluded that the necessary legal framework for both conventional and radiation emergencies is available. However, many provisions in NR-EPR regulations need to be re-evaluated. Some of the provisions, especially in NERA's chairman regulation on Nuclear Emergency Preparedness and Response (NEPR), are no longer valid. The validity of the NEPR is strongly related with the general provisions on NR-EPR, which are governed in the

government's regulation on the Safety and Security of Nuclear Installations (SSNI). The SSNI was established two years after the enforcement of the NEPR.

In addition to the validity of its provisions, there are more reasons which necessitate revision of the NEPR. Most of the provisions in the NEPR are still at conceptual levels, making its enforceability necessarily low. The allocation of responsibilities for emergency response specified in the NEPR is also not clear. For instance, one part of the document states that the on-site emergency responders are responsible to take all response actions during a general emergency situation. A general emergency situation is declared by facilities in threat categories I and II (see Table 3 about threat categorization) when the emergency affects the area outside of the facility boundaries. In this situation, the regulation requires the facility operator to conduct radiological assessment in the precautionary action zone (PAZ), urgent protective action planning zone (UPZ), and the food restriction planning radius. This arrangement becomes unreasonable because these areas vary greatly and can range from 3 to 300 km (Republic of Indonesia, 2010). It is unlikely that only facility responders can perform these duties unless there is coordination with the government and the off-site responders. Although the regulation requires coordination between the facility with the off-site responders, it does not specify the scope of duties of the off-site responders.

Without a proper allocation of responsibilities, the emergency response could be ineffective due to confusion and the confict of information between the emergency responders (IAEA, 2003). Hence, it is important to specify the responsibilities of the facility and off-site responders in the emergency situation. The regulation has to define

when the emergency situation requires the involvement of the off-site responder. The delegation and transfer of responsibilities between the facility, local and national responders must also be specified, as well as the process on how the delegation and transfer of responsibilities is performed.

The current provisions in the NEPR and SSNI regarding the declaration on emergency situations also bear potential conflict. Both regulations require the declaration of emergency situation based on different classifications. The SSNI classifies the emergency situation into 3 classes: facility, local, and national emergency. This classification differs from emergency class in the NEPR, which consist of alert, site area emergency and general emergencies. Compatibility of the emergency classes is very important because the subsequent response actions will be based on these classifications. For this reason, the differences between the emergency classifications must be resolved.

The compatible emergency classes can be incoorporated in the revision of the NEPR. Prior to establishing the proper classification terminology, there are some considerations which need to be taken into account. First, the emergency classification should be harmonized with the IAEA's classification because emergency situations could also involve an international response. It is important to have the common classification to avoid misinterpretation of the emergency situation and to facilitate the response operations. Table 1 presents the current Indonesian radiation emergency classification and the proposed classification based on the IAEA recommendation. Second, revision to the emergency classification in the SSNI need to be avoided considering that changing a provision in a government regulation would require

extensive efforts. It is inefficient to revise the SSNI while the provisions can be corrected without compromising the legality of the regulation. This can be done by attaching the proper classification into the existing group in the SSNI. Hence, the revision of NEPR will specify the emergency classification as follow:

1. Facility emergency

   A facility emergency could result from site area emergency, facility emergency, alert, and other emergencies. The declaration of facility emergency has to be specified based on these specific classes.

2. Local emergency

   A local emergency could result from general emergency and other emergencies. It is declared as local emergency when the limit specified in the SSNI is exceeded.

3. National emergency

   A national emergency could result from general emergency and other emergencies. It is declared as national emergency when the limit specified in the SSNI is exceeded.

Table 1. This table presents the current Indonesian radiation emergency classification and the proposed classification based on the IAEA recommendation.

Current Classification in Indonesia (Republic of Indonesia, 2010)	**Proposed Classification based on IAEA guidance (IAEA, 2003)**
General emergency Declared by the facilities in threat category I and II, when the emergency affaects the area outside of the facilities.	**General emergency** This emergency class applies to facilities in threat category I and II as the result of a loss of shielding, or a criticality in the reactor that would cause the release of radioactive material or radiation exposure. Hence, the facility's operator, local and/or national officials must have arrangements available that anticipate the possibility of the escalation of the emergency beyond the facility's border. When a general emergency occurs, protection of the people, environment, and property outside the facility and in the EPZs becomes the main objective of the national response.
Site area emergency Declared by the facilities in threat category I and II, when the emergency affects the area inside of the facilities.	**Site area emergency** Site area emergency should be identified at facilities in threat category I or II when there is significant decrease of radiation protection on-site and near the facility. Off-site response is not necessarily warranted; however, arrangements must be available at the facility, local and/or national level for protective actions on and off the site.

Table 1. Continued

Current Classification in Indonesia (Republic of Indonesia, 2010)	Proposed Classification based on IAEA guidance (IAEA, 2003)
-	**Facility emergency** Facility emergency occurs at the facilities in threat category I, II, or III due to significant decrease of radiation protection on the site. In this case, off-site response is not required
Alert Declared by the facilities in threat category I, II, and III, when the emergency occurs in a building inside of the facilities.	**Alert** The facility's operator in threat category I, II, or III must release an alert when there is significant or uncertain decrease of radiation protection on the site. On-site or off-site response organizations might not be activated unless the mitigatory actions fail to terminate the emergency situation.
-	**Other emergencies** Other emergencies such as loss, theft, or lack of control of radioactive material due to malicious acts, illicit trafficking, and similar causes

Although the IAEA suggests that the regulatory infrastructure does not have to be complete prior to starting the development of the NR-EPR plan, the necessary requirements for performing emergency response operations need to be identified and complemented during the planning process (IAEA, 2003). The following paragraphs discuss the requirements for national response which have not been incoorporated in the current Indonesian NR-EPR regulations. The importance of enforcing the requirements and the strategies to develop the regulations are also addressed.

4.1.1. Requirements for radiation emergency facilities to be established prior to and during the emergency situation.

The IAEA recommends the establishment of emergency facilities and locations for conducting emergency operations prior to or during the emergency situation. The facilities include, but are not limited to: the designated and referral hospitals, assistance centers, emergency operation facility, and radiological monitoring and assessment center (IAEA, 2003). The requirements for establishing these facilities, the responsible agencies and the process of a facility's activation have to be specified in the regulation. While preparing the regulation governing the radiation emergency facilities, the NERA must identify the facilities that will be established in advance, such as the designated and referral hospitals. These hospitals must have personnel who have adequate knowledge and skill as well as equipment for the treatment of radiation exposure and contamination (IAEA, 2003). Identifying locations such as these in advance is useful to determine the future need for equipment and personnel training.

4.1.2. Requirement for the urgent protective actions which have to be taken by the off-site responders during the general emergency and site area emergency for the facilities in threat category I and II.

Selecting the appropriate protective actions, in the case of a radiological emergency, is heavily affected by the potential of deterministic effects, the possibility of stochastic effects, and the adverse effects of radiation exposures to the environment, to property, and the economy (IAEA, 2011). Establishing these protective actions in a timely manner is required to protect the affected population. In the planning process, a system of protective actions, which consist of a series of dose criteria and the corresponding response actions, has to be developed to assist decision makers in taking the necessary urgent protective actions.

There are documents that can be useful in developing these protective actions. In the Unites States protective action guides (PAGs) were developed by the Environmental Protection Agency (EPA). These are based on the projected dose to a reference man through various exposure pathways during the early, intermediate, and late phases of an incident. These are used by the authorities at various levels to develop the relevant emergency plans (EPA, 1992). A more recent document for developing the protective actions criteria is established by the IAEA. The concept of protective actions is similar to the EPA PAGs, in that the IAEA recommends the implementation of protective actions based on predefined criteria. These criteria are divided into two categories (IAEA, 2003):

a. Generic criteria

The generic criteria for protective actions are generated based on dose that has been projected prior to an incident and dose that has been received due to the incident. However, these criteria are not measurable values. For example, iodine thyroid blocking should be taken when it is projected that the first 7 days of an incident would cause an equivalent dose of 50 mSv to the thyroid. This criterion is not practical for the actual measurement, thus default operational criteria have to be developed.

b. Operational criteria

The operational criteria consist of emergency action levels (EALs), operational intervention levels (OILs), and observable indicators on the scene. The EALs correspond to emergency classification and are determined based on the observable threshold instrument readings in the facility. The OILs are measurable values generated from the generic criteria and are expressed in dose rate, activity, or activity concentration. Measured OILs apply to radioactive material released, time integrated air concentrations, ground or surface contamination, environmental or food contamination. Figure 5 illustrates the relationship between generic and operational criteria.

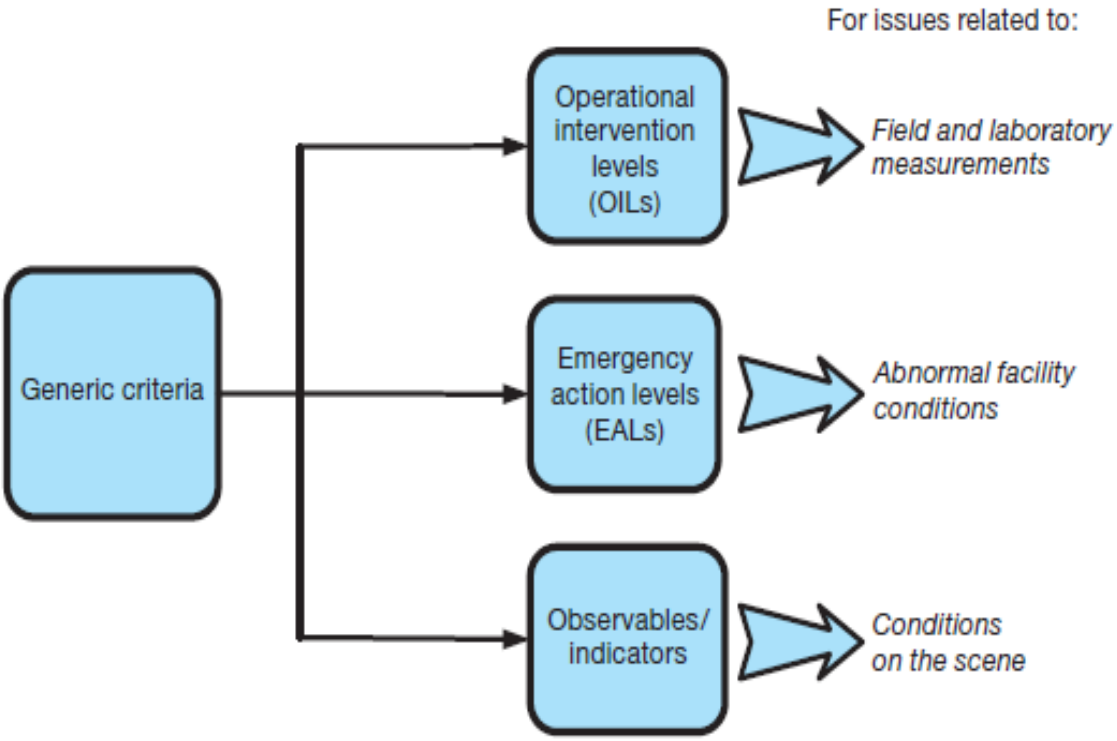

Figure 5. This figure illustrates the relationship between the generic and the operational criteria (IAEA, EPR 2003).

Developing the PAGs would be the responsibility of the NERA, as the national regulatory authority in Indonesia. The IAEA's generic intervention criteria will initially need to be adopted, followed by developing the default OILs. The EPA PAGs and International Commission on Radiological Protection (ICRP) guidance would be valuable references for developing the OILs as they provide methods for deriving the operational limits.

4.1.3. The central government's roles in providing and issuing warnings to the public in regard with national emergency.

The central government's roles in providing and issuing warnings to the public, in the case of radiation emergency have to be defined in the regulation. The process of information and warning dissemination must be defined though regulation for an effective emergency response. This system has been applied in the United States. The NRF defines the emergency management authority responsible to provide prompt and reliable information to decision makers and the public regarding any emergency situation and the necessary actions being taken (NRF, 2013). The provisions in the current NEPR which require the facility to issue the information and warning to the public has to be corrected. The role for releasing such information has to be given to the national authority; the facility will support by updating the proper information provided to the authority.

4.1.4. Requirements for protecting the emergency workers.

The IAEA defines the emergency workers as the people who have the risk of being exposed to radiation during their work in mitigating the consequences of a radiation emergency (IAEA, 2007). The emergency workers include the fire fighters, law enforcement, medical personnel, drivers and evacuation crews, radiation specialists, radiation protection officers, and radiological assessors (IAEA, 2002). Since their working environment may pose a high radiation risk, there must be sufficient regulatory

arrangements for keeping these workers protected. The regulation must include, at a minimum:

a. the provisions for performing radiological monitoring and long term radiological assessment;
b. provisions to provide procedures for maintaining the dose limits and contamination levels;
c. assigning responsibility to provide protective equipment and training for the emergency workers; and
d. the corresponding OILs for emergency workers.

4.1.5. The criteria for taking agricultural countermeasures, countermeasures against ingestion, and longer-term protective actions.

The current regulation does not specify the criteria for taking agricultural countermeasures, countermeasures against ingestion, and longer-term protective actions. These criteria are important to facilitate the necessary actions for protecting segments of the population who may consume contaminated food products (IAEA, 2007). Besides the protective actions criteria, there must be criteria for restricting access to the contaminated area and to relocate the people living around the affected zones. These criteria can be established based on the default OILs for controlling the agricultural products and relocation. The requirement can be satisfied by imposing the responsibility on the relevant government agencies for restricting the consumption and the distribution\sale of contaminated agricultural products.

4.1.6. Safety and security areas

The concept of inner cordoned area radius or the safe distances has not been regulated in Indonesia. The safe distances are mostly applied to the emergency situations due to a transport accident involving radioactive materials, radiological dispersal devices, or explosion/fire involving nuclear weapons. The implementation of the safe distances during these situations is aimed to reduce the potential risk of radiation exposure to the public and the first responders. To ensure its applicability, it is important to enforce these default values into the regulation. It is also beneficial to include the safety perimeters in the national NR-EPR plan to facilitate the development of relevant EPR plans and procedures by relevant response agencies. The inner cordoned area radius or the safe distances, based on the IAEA EPR-Methods is presented in Table 2. Once this task is done, Task 2 of this method will be completed.

Table 2. The suggested safe distances which have to be implemented for specific emergency situations (IAEA, 2003).

Situation	Safe Distances
Intact package with a I-WHITE, II-YELLOW or III-YELLOW label	Immediate area around the package
Damaged package with a I-WHITE, II-YELLOW or III-YELLOW label	30 m radius or at: - Ambient dose readings of 100 μSv h^{-1} - 1000 Bq cm^2 gamma/beta deposition - 100 Bq cm^2 alpha deposition
Undamaged common source (consumer item) such as smoke detector	None
Other unshielded or unknown source (damaged or undamaged)	30 m radius or at - Ambient dose readings of 100 μSv h^{-1} - 1000 Bq cm^2 gamma/beta deposition - 100 Bq cm^2 alpha deposition

Table 2. Continued

Situation	Safe Distances
Spill	Spill area plus 30 m around
Major spill	Spill area plus 300 m around
Fire, suspected radiological dispersal devices, explosion or fumes, spent fuel, plutonium spill	300 m radius (or more to protect against effects of an explosion) or at - Ambient dose readings of 100 μSv h^{-1} - 1000 Bq cm^2 gamma/beta deposition - 100 Bq cm^2 alpha deposition
Explosion/fire involving nuclear weapons (no nuclear yield)	1000 m radius or at: - Ambient dose readings of 100 μSv h^{-1} - 1000 Bq cm^2 gamma/beta deposition - 100 Bq cm^2 alpha deposition

4.2. Task 2: Perform threat assessment

The second task in the graded approach methodology is performing a threat assessment. For the purpose of the national NR-EPR plan, this task is intended to identify the practices and facilities in the whole country, which pose radiation and non-radiation hazards due to its operations. Identifying these hazards will allow for designing the appropriate actions to be taken during a response. The IAEA categorizes these hazards or threats into 5 groups to facilitate the planning for emergency response. This categorization has been adopted in NEPR, hence it should be used as the reference for performing the threat assessment. The description of the threat category is provided in Table 3.

Table 3. List of threat categories for facilities and activities based on the IAEA categorization (IAEA, 2002).

Threat category	Description
I	Facilities, such as nuclear power plants, for which on-site events (including very low probability events) are postulated that could give rise to severe deterministic health effects off the site, or for which such events have occurred in similar facilities
II	Facilities, such as some types of research reactors, for which on-site events are postulated that could give rise to doses to people off the site that warrant urgent protective action in accordance with international standards, or for which such events have occurred in similar facilities. Threat category II (as opposed to threat category I) does not include facilities for which on-site events (including very low probability events) are postulated that could give rise to severe deterministic health effects off the site, or for which such events have occurred in similar facilities
III	Facilities, such as industrial irradiation facilities, for which on-site events are postulated that could give rise to doses that warrant or contamination that warrants urgent protective action on the site, or for which such events have occurred in similar facilities. Threat category III (as opposed to threat category II) does not include facilities for which events are postulated that could warrant urgent protective action off the site, or for which such events have occurred in similar facilities
IV	Activities that could give rise to a nuclear or radiological emergency that could warrant urgent protective action in an unforeseeable location. These include non-authorized activities such as activities relating to dangerous sources obtained illicitly. They also include transport and authorized activities involving dangerous mobile sources such as industrial radiography sources, nuclear powered satellites or radio-thermal generators. Threat category IV represents the minimum level of threat, which is assumed to apply for all States and jurisdictions.
V	Activities not normally involving sources of ionizing radiation, but which yield products with a significant likelihood of becoming contaminated as a result of events at facilities in threat category I or II, including such facilities in other States, to levels necessitating prompt restrictions on products in accordance with international standards.

A simple threat assessment was conducted to identify the existing practices and facilities in Indonesia, which fall into each category in Table 3. The results of this

assessment are presented in Table 4. Locations of some facilities and activities cannot be defined in the table because they are not in fixed locations, such as the transport of radioactive material. Therefore, a more comprehensive threat assessment should be undertaken by the government to provide a better vulnerability analysis of Indonesian activities The following should be included in the analysis: the origins, destinations, transits and routes for radioactive material, and the probability of locations where radioactive sources are illicitly transported, abandoned, or stolen (IAEA, 2007).

The threat assessment also has to include the description of the EPZ for the facilities in threat categories I and II. Determination of the EPZ is important because the implementation of the off-site urgent protective actions (i.e., sheltering and evacuation) will be based on the EPZ (IAEA, 2007). Indonesia currently does not have a NPP, which falls into threat category I, therefore the threat assessment for the EPZ will only apply for the facilities in threat category II. The description of the EPZ in the form of a map, should be presented in the NR-EPR plan.

After completion of the threat assessment in Task 2, developing the planning basis for the EPR plan in Task 3 can be initiated.

Table 4. List of the current threat category based on Indonesian EPR regulation.

Threat Category	Facility or Activity	Number of Facilities or Activities	Location (Province)
I	Nuclear power plants	None	None
II	Research reactors	2	Banten, D.I. Jogjakarta
	Radioactive waste management center	1	Banten
III	Research reactor	1	West Java
	Nuclear Fuel Element Fabrication	2	Banten
	Radioisotope production	1	Banten
	Irradiator category IV	2	DKI Jakarta, West Java (Bekasi)
	Radiotherapy facility	13	South Sumatera, West Sumatera, DKI Jakarta, East Java, West Java, Central Java, DI Jogjakarta, South Kalimantan, Bali
	Industrial radiography – closed (secured) facility	None	None
IV	Industrial radiography – open facility	520	Most Provinces
	Well logging	1539	Most Provinces
	Gauging – high activity	1512	Most Provinces
	Transport of radioactive material	Unidentified	Unidentified
V	Trans-boundary release, import of contaminated products	Unidentified	Unidentified

4.3. Task 3: Develop planning basis

The planning basis is developed based on the threat assessment. After collecting the necessary information about the existing threat categories, the possible emergencies which could happen in each threat category and the response plan for the emergency situations should be addressed in the NR-EPR plan. To develop the national planning basis, some information first needs to be collected. For example, the information about availability of medical, police, and fire fighting teams, sheltering, and transportation for evacuation purposes. Collecting this information requires the involvement of the relevant agencies having duties in these areas. The necessary information for the planning basis as well as possible agencies in Indonesia to provide such information, are presented in Table 5. The list of the information in the table is adapted from the IAEA EPR-Methods (IAEA, 2003).

The next tasks in the graded methodology are developing a concept of operations and allocating the responsibilities for response operations. These tasks actually can be performed in parallel with developing the planning basis. Considering that the tasks will involve the same agencies, it is actually beneficial to simultaneously perform these two tasks. However, for discussion purposes, Task 4 is elaborated separately.

Table 5. List of information which is required to develop the planning basis for the NR-EPR plan.

No	Threat Category	Information	Responsible Agencies
1.	1,2,3	Medical, police and fire fighting support available	Ministry of Health, National Police Department, Ministry of Internal Affair
2.	1,2	Typical sheltering available in the UPZ	NBDM, Ministry of Internal Affair
3.	1,2	Typical transportation available for evacuation within the UPZ	NBDM, Ministry of Transportation
4.	1,2,3,4,5	Communications available for decision makers	NBDM, Ministry of Communication and Informatics
5.	1,2,3,4,5	Communications available to alert and inform the public	NBDM, Ministry of Communication and Informatics
6.	1,2,3	Locally produced food and milk that may be directly contaminated	Ministry of Agriculture, Ministry of Commerce, NNEA
7.	1,2,3	Information on agricultural product collection and distribution system	Ministry of Agriculture, Ministry of Commerce
8.	1,2,3	Drinking water supply systems	Jasa Tirta., Co
9.	1,2	Population distribution	Statistics Indonesia
10.	1,2	Special populations (e.g., hospitals) and transients within UPZ	Statistics Indonesia
11.	1,2	Special facilities (e.g., factories that cannot be evacuated) that may be affected by the emergency	Ministry of Industry, the government
12.	1,2	Transportation systems that may be affected by an emergency (e.g., road, rail, air, sea, canals)	Ministry of Transportation
13.	1,2,3	Points of import and export of food	Ministry of Commerce
14.	1,2,3,4,5	Range of weather conditions under which protective actions and monitoring may be conducted	National Agency for Meteorology, Climatology, and Geophysics
15.	1,2,3,4,5	Severe conditions that may result in an emergency	NNEA, NERA

4.4. Task 4: Develop concepts of operations and allocate responsibilities

The IAEA emphasizes the importance of proper and clear allocation of responsibilities in the NR-EPR plan. To assist allocation of the responsibilities, the IAEA provides a list of response actions, which need to be taken during an emergency. The list of response actions is commonly known as critical tasks. Instead of assigning the critical tasks to particular agencies, the IAEA suggests that the agencies indicate which tasks apply to them as well as their resources and capabilities to perform the tasks (IAEA, 2003). In Indonesia, the NERA as the NCA should bear the responsibility to distribute the critical tasks to the relevant agencies and ensure that every task is paired to a responsible agency. Overall, completion of the list of critical tasks will enable the identification of Indonesia's national resources, and to identify the future needs for the establishment of the necessary assets.

The critical tasks from the IAEA EPR-Methods cover a broad range of responsibilities, including those which should be assigned to a facility. To better align with the Indonesian NR-EPR plan, adjustments were made to the IAEA's suggested critical tasks. These results are presented in Table 6. The agency for each task is assigned based on the applicable Indonesian EPR regulation; some of them are proposed based on the need for conducting the tasks. The final list of agencies, which will be responsible to perform the critical tasks, can be determined once the NCA completes the distribution of the initial list.

Table 6. List of critical tasks adopted from the IAEA EPR-Methods and the agencies which are suggested to perform the tasks.

Threat Category	Critical Tasks	Agencies
1,2,3,4,5	Coordination for national radiological planning (national coordinating authority)	NERA
1,2,3,4,5	Coordination for national conventional response planning	NBDM
1,2,3	Coordination for local off-site planning (radiological and conventional)	LDMA
1, 2, 3, 4	Notification of other States and requesting international assistance	NERA
1,2,3	Making decisions on urgent protective actions	Team (NERA, NBDM, NNEA)
1,2,3	Implementing urgent protective actions	The government (jurisdiction)
1,2,3	National coordination of emergency service standards and training	NERA
1, 2, 3, 4	Providing emergency service support	The government (jurisdiction)
1, 2, 3, 4	Providing response to criminal activities (tactical response and investigation)	POLICE
1,2,3	Making decisions on longer term and ingestion protective actions	Team (NERA, NBDM, NNEA)
1,2,3	Implementing longer term and ingestion protective actions	The government (jurisdiction)
1,2,3,4,5	Coordination with the media	NBDM
1, 2, 3, 4	Off-site monitoring and laboratory analysis capabilities	NNEA

After assinging appropriate responsibilities to pertinent agencies, the concepts of operations for the threat response as a function of threat category can be developed. Prior to this process, a general threat description which leads to an emergency situation should be described. The description contains the postulated emergency events, and how an emergency situation may and may not develop. The concepts of operations describe the scenario to implement the response actions based on the threat description. It should also

include the appropriate response agencies to be deployed during the events. The IAEA suggests that the concept of operations are developed based on two principles: the emergency response is operated under the incident command system and a single location is used to release the information to the public (IAEA, 2003). The default concepts of operations based on these principles are provided in the IAEA EPR-Methods and can be adopted into the NR-EPR plan. Also, the Nuclear/Radiological Incident Annex of the NRF can be used as additional reference. For this task, the NCA has to ensure that all necessary resources and arrangements as described in the concepts of operations are available or prepared.

Once the concepts of operations and allocation of responsibilities are performed, Task 5 of the graded approach methodology could be performed. At this point, most of the weaknesses in the current EPR system and the need for improvements should have already been identified.

4.5. Task 5: Develop interim capabilities

Developing interim capabilities is suggested by the IAEA as a mean to increase the awareness and preparedness for a radiation emergency while the development of the NR-EPR plan is in progress (IAEA, 2003). In this step, the regulatory basis for the NR-EPR can be completed, the weaknesses in the current EPR system can be addressed, and the necessary resources for the NR-EPR can be prepared. Another means for increasing the interim capabilities is to provide appropriate training for the emergency workers. This training can be conducted as a joint-operation between the NBDM and NERA.

In addition, it is also beneficial to build a communication portal to link all emergency response agencies. The communication portal can be in the form of internet-based media managed by the NCA. With this portal, all progress on the development of the EPR system can be updated by the relevant agencies. Internet-based media also allows reliable, rapid information sharing. This will also help prevent further delays in this process. The concept for multi-agencies communication portal would be a potential solution to close the gap of communication between the emergency authorities in Indonesia and promote the integration of the EPR system.

4.6. Task 6: Write national NR-EPR plan

Once the proper information from task 1 to task 5 of the graded methodology is available, the process of writing a NR-EPR plan can be performed. The plan must include common terminologies used in the EPR, threat assessment and ideal response to the threat (the concept of operation based on the existing threat categorization), description of the roles and responsibilities of every agency involved in the response, incident command system (ICS) structure and components, coordination between the response agencies, procedures, training and exercises. An outline of the NR-EPR plan, based on the IAEA EPR-Methods, is presented in the appendix. For an integrated emergency plan, LDMA, facilities, and response agencies must each draft their own individual plan based on the national EPR plan.

5. CONCLUSIONS

5.1. Conclusions

In preparing the future plans for nuclear power, and to anticipate potential radiation emergencies from the current practices, Indonesia has to establish a national NR-EPR plan. This plan will be the basis to conduct radiation response activities and will become the core of a national radiation response framework. The establishment of the plan cannot be conducted merely based on the NR-EPR concept, but must be fully integrated with conventional emergency management.

Although the arrangements for the EPR framework have been promoted in current regulations, the development of a national NR-EPR plan has been hindered. The main issue that has caused the delay is related to poor inter-agency coordination. The NBDM and NERA as the two main agencies responsible for establishing and coordinating the NR-EPR plan have not been able to execute their functions in emergency management. To resolve the coordination problem, it is suggested that the two agencies establish a legally binding agreement as the platform for coordination. The agreement must contain a detailed description of each agency's responsibilities.

In addition to the coordination issue, there are also challenges in developing the integrated EPR system. First, developing the integrated EPR system requires human and financial resources and these have not been included in NBDM program. The current NBDM program is focused on the natural disasters. Second, Indonesia does not have a general emergency framework, consequently the NR-EPR plan must be detailed and

comprehensive. To address the first challenge, the NBDM has to include the radiation hazards from practices and facilities in the DM plan, including its proposal to develop the integrated EPR system. The second challenge for creating a comprehensive NR-EPR plan could be addressed by implementing the IAEA's integrated planning concept.

The IAEA's integrated planning concept is developed by using a graded approach methodology. The methodology consists of ten tasks, which need to be implemented gradually. The research presented in this thesis applied portions of the graded methodology to assess current Indonesian capabilities for radiation emergency and prescribed improvements. The ultimate purpose of this methodology is to create an integrated emergency response system, where the preparedness for radiation emergency response is built around the national all-hazards plan and complemented by the relevant plans at the facility and local levels. This graded methodology allows for a thorough evaluation, and ultimately strengthening of national response capabilities, correcting the defects in the current system, and building an integrated EPR plan.

5.2. Future Work

The results of this research could be used as the basis for developing the NR-EPR plan and reform the overall EPR system. A more comprehensive threat assessment will need to be done to develop the planning basis and concept of radiation response operations. The overall future work will need to involve the coordination between the relevant emergency response agencies. The national NR-EPR plan could be established when the integrated planning concepts are fully adopted and implemented.

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APPENDIX

The IAEA suggested the following outline for NR-EPR plan. More detail information about developing the outline can be found in the IAEA EPR-Methods 2003.

I. INTRODUCTION
- 1.1 Purpose
- 1.2 Participating Organization
- 1.3 Scope
- 1.4 Legal Basis
- 1.5 Related Plans and Documents

II. PLANNING BASIS
- 2.1 Types of threat
- 2.2 Terms
- 2.3 Response roles and responsibilities
- 2.4 Response organization
- 2.5 Response facilities
- 2.6 Response communications
- 2.7 Logistic/resources commitments
- 2.8 Concepts of operations

III. EMERGENCY RESPONSE PROCESS
- 3.1 Notification, activation and request for assistance
- 3.2 Emergency management
- 3.3 Performing mitigation
- 3.4 Taking urgent protective action
- 3.5 Providing warnings and instructions to the public
- 3.6 Protecting emergency workers
- 3.7 Provide medical assistance and mitigating the non-radiological consequences
- 3.8 Assessing the initial phases
- 3.9 Keeping the public informed (media relation)
- 3.10 Taking agriculture, ingestion and longer-term countermeasures
- 3.11 Conducting recovery operations
- 3.12 Financing operation
- 3.13 Maintaining records and management of data

IV. EMERGENCY PREPAREDNESS PROCESS
- 4.1 Authorities and responsibilities
- 4.2 Organization