Management of Site Evaluation: A Lesson Learnt of 10 MW HTGR Experimental Power Reactor (RDE) Project Site Licensing

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Abstract. In 2013, a pre-project activity of Experimental Power Reactor (RDE Project) was started. The reactor type is a High Temperature Gas-cooled Reactor (HTGR) with a 10 MWth capacity. At present the project has been postponed due to some reason, however, there was an important stage that has been achieved, regarding the site evaluation process to obtain site permits from the Regulatory Body (BAPETEN). Site evaluation is an critical activity that will guarantee the safety of nuclear facilities from natural and human induced external events as well as the safety of population and the environment due to nuclear facility accidents. Site evaluation for the RDE project has the same process as a large NPP project, considering that at the time of the site evaluation process there were no specific regulations that considered a graded approach for a mini-scale NPP. The site evaluation process includes two stages, namely 1). Site Evaluation Program (SEP) and Management System of Site Evaluation (MSSE) Approval and 2) Site Evaluation Approval. SEP is intended to establish the scope and criteria for site evaluation safety. Whereas the Site Evaluation Management System is a managerial instrument that makes site safety as the top priority in each activity and process of RDE site evaluation. BATAN as the project owner delivered the SEP document and MSSE to BAPETEN on March 10, 2014. These documents was intensively discussed by BAPETEN and BATAN to determine agreement on the scope of site evaluation, criteria and management aspects based on site safety considerations. The technical aspects that must be evaluated are seismicity, volcanic hazard, geotechnical and foundation, meteorology, hydrology, human induced events, dispersion and population distribution. This document was approved by BAPETEN on March 2, 2015. Considering the very wide scope with various fields of competence and need supporting data for evaluation, this can not be done only by BATAN experts, it must collaborate with various institution that have competence related to the site aspect. The experts that involved in the site evaluation come from Meteorology and Geophysics Agency (BMKG) for seismic and meteorological aspects, Geospatial Information Agency (BIG) to support geospatial data and ground movements/deformation, Geological Survey Center (PSG) to support geological data and geological structures, Center for Volcanology and Geological Disaster Mitigation (PVMBG) to support volcanic catalog data and volcanic hazard, University to support geotechnical, foundation and hydrology evaluation. BATAN experts from various Centers involved for evaluating topography, human induced events, dispersion, dose assessment, population distribution, emergency preparedness, and technology aspects. Data acquisition activities such as geophysics, drilling, geological mapping, volcanic mapping, hydrology, satellite imagery and digitizing processes are contracted through third parties with guidance developed by the BATAN Expert Team. Considering the very limited time and financial resources availability, in order to achieve the effectiveness of all activities, a special organization was formed to control site
evaluation with the BATAN Chairman as Top Management. The Site evaluation document was submitted in two stages. The first stage is administrative completeness and it was declared administratively complete on November 15, 2015. The second step is BAPETEN assessed and evaluated the technical documents submitted to determine the acceptability of the site. The process of evaluating the site evaluation document lasts quite a long and intensive. Finally, the site permit was issued on January 23, 2017.

The valuable lessons during the site evaluation project are: 1) It requires the same understanding and perception between applicant and regulator regarding the site licensing process; 2) The establishment and implementation of an effective organization; 3) controlling the project schedule.

1. Introduction
The RDE Project is a project to build an experimental power reactor with main objectives to conduct experiment, demonstrating safety and performance of reactor and increasing human resource capacity. The idea of the project was started in 2013, and implementing of the pre project activities started in 2014. The RDE to be built is a High Temperature Gas-cooled Reactor (HTGR) reactor type with a capacity of 10 MWth [1]. At present the project has been postponed due to some reason, however, there was a crucial stage that has been achieved during the pre-project activities. Site evaluation process has been carried out successfully resulting a site permits from the Regulatory Body (BAPETEN) on January 23, 2017. This is the first experience for both applicant (BATAN) and regulatory body (BAPETEN) in the process of nuclear reactor site licensing.

Good data management is important not just for selecting and licensing the best site, but also to help to resolve possible future issues that arise during operations and require further justification [2].

2. Problems
Site licensing process for nuclear power involves a lot of technical and non-technical problems that must be well managed to achieve site permit in a proper time. From a technical point of view, availability data on site is very limited, so it needs hard work in data acquisition and analysis. The scope of study includes:

a. Seismic hazard evaluation needs a lot of supporting data such as detail topographic map, satellite imagery, detailed geological maps, confirmed geological structure, geophysical data, earthquake catalogs, ground deformation with the objective to ensure that there are no capable faults in the site vicinity as well to build a proper seismotectonic models as a basis for seismic hazard analysis for both deterministic and probabilistic method [3]. To meet the Indonesia regulation for site permit, it must be proven that the level of seismic (peak ground acceleration-PGA) on the site should be still meets the acceptance criteria, which is 0.6 g for a 10,000-year return period. If the PGA level on the site exceeds 0.6 g, the site will be rejected [4].

b. Geotechnical hazard evaluation requires supporting data such as depth of bed rock, lithology, drilling data with in situ tests and laboratory tests for soil characteristics of each lithology layer [5], stratigraphy, slope analysis based on detail topography map and the layout of nuclear facilities to be built. Soil characteristic (i.e. shearwave velocity, Vs) should be able to support the reactor building load and there will be no geotechnical hazards such as liquefaction in the event of an extreme earthquake. Therefore, a systematic drilling (with geophysical logging) is needed to ensure site safety from geotechnical hazards and also to provide input data for the design of foundations and building structures, especially for nuclear reactors. Other geotechnical hazards such as sinking, ground collapse, land subsidence, landslides in the site must be proven not to occur in the site area. This requires data support through geophysical investigation [6].

c. Evaluation of volcanic hazard is conducted within radius 150 km from the site. The site is located in the geological area of volcanic products. Within a 25 km radius of the site there are several old volcanoes (Mt. Pengki, Mt. Sodong, Mt. Dago, Mt. Pagutan and Mt. Sudamanik), which have to be proven by identification of their eruption age through K/Ar dating analysis. The results of the dating, they have age > 7 ma [7]. While active volcanoes within a radius of 150 km there are 90 volcanoes with an age of early Miocene to Holocene. For the site evaluation
purpose, it had been selected 2 nearest active volcanoes (agreement with regulatory body) from the site that have the most significant potential impacts on the site, namely Gede Volcano and Salak Volcano. The evaluation should prove their capabilities and impacts from any volcanic phenomenon (pyroclastic flow, lava flow, lahar flow, volcanic ash, bombs, debris avalanches, groundwater anomalies, opening new vents etc.) to the site [8] [9]. Volcano mapping is made in detail to identify all volcanic products (both of primary and secondary) around the site. Other phenomena such as hot spring (9 km distance) are also analyzed through geochemistry analysis to ensure that the occurrence of hot spring is not influenced by gas release from magma system which is indicated by low concentration of magmatic chemical component (sulfate and fluoride).

d. Evaluation of hydrological hazards. River flooding (the site location is near the Cisadane River) is one of the potential hazards that can threat the safety of the nuclear reactor, so it must be proven that the site meets with the criteria of extreme river flooding. Factors that may influence the magnitude of river flooding are extreme rainfall (based on long term data from nearest meteorological station), river configuration in the upstream area to determine the catchment area, river dimensions (hydro-morphology), topography around the site, site platform (based on design) [10] [11]. Simulations were carried out for extreme flood with 1000 and 10,000 years return period and described areas affected and inundated by floods, to evaluate site acceptance. Floods that have come suddenly due to structural failures in the upstream area must also be carried out, so that the collection of all structural data is also required. River floods are also analyzed based on past events with regard to sediment deposits. It was also measured groundwater levels at the determined monitoring wells, to ensure that the probable maximum ground water level is still acceptable.

e. Meteorological aspects. Meteorological data collection (i.e., temperature and its temperature lapse rate, relative humidity, wind speed, wind direction, air pressure, solar radiation, lightning) was conducted through a) secondary data collection (minimum 30 years) from meteorological stations closest to the site (owned by Meteorological, Geophysical and Climatological Agency-BMKG) and b) from primary data through on-site meteorological station monitoring. Meteorological evaluation is carried out for 3 purposes, namely 1) to evaluate the hazard of meteorological rare events phenomena (such as tropical cyclones, tornadoes, storms, etc.), 2) to determine the design basis parameters with a certain return period (such as probable maximum temperature, probable maximum rainfall, etc.) and 3) to determine the atmospheric dispersion parameters due to radionuclide release from reactor from both normal operation and worst-case accident scenario. On site meteorological monitoring is carried out continuously until the reactor operation is complete.

f. External Human Induced Events (EHIE) aspect. Around the RDE site there are sources of human activity that have the potential to threat the safety of the nuclear reactor. In principle, it can be divided into fixed source (such as airports, industries, military bases, fuel stations, oil and gas depots, etc.) and mobile sources (including air traffic, gas pipelines, railway, highways). Potential hazards of fixed sources were evaluated based on potential of explosions, fluid releases, cloud releases, toxic vapors, etc. The analysis was carried out through the Screening Distance Values (SDV) and Screening Probability Level (SPL) approach [12]. The determination of the radius of SDV used in initial screening is based on references and discussions result with regulators. Furthermore, the analysis of the acceptability of all EHIE sources within the SDV radius is based on simulations taking into account the potential sources, intensity of accident (i.e., explosion) protection systems, distribution zone of the accident impacts (missile, toxic fluid, flammable material, etc.) to the reactor site.

g. Dispersion and Population distribution Aspect. Dispersion analysis was carried out for both normal operation and accident postulated releases (by using worst case accident). The purpose of the evaluation of dispersion and radiation dose assessment is to prove that the radionuclide release due to the both normal operation and accident of the RDE will remain safe for the worker, population surrounding the site and environment [13]. Data that needed for the evaluation
among other meteorological data (statistic of wind speed, wind direction, temperature lapse rate, stability of atmosphere, solar radiation, etc., which is supplied by meteorological aspect), population distribution, land and water use, topography, dietary habit, etc. The data of population distribution was collected from Statistical Agency, interpretation of satellite imagery and ground survey for validation [14]. For evaluation purposes it was supported by some software for source terms calculation and dispersion analysis. Dose assessment is carried out by considering the initial (existing) dose received by the population and then added by radiation dose due to the release of radionuclides from RDE. In the calculation of radiation doses, it was considered existing nuclear facilities around the site such as the GA Siwabessy research reactor (30 MW), radioisotope production, nuclear fuel installation, and radioactive waste treatment.

To ensure the quality of processes and results, all activities were conducted by referring to the Management System of Site Evaluation (MSSE) and the results of its implementation are reported in the Site Management Evaluation System Implementation Report, which includes internal and external audit reports (BAPETEN), inspection reports, management review, etc. MSSE will be as control and verification system for all RDE site evaluation activities which will impact to the quality (process and product) as well safety aspect [15].

Based on the non-technical side, the obstacle and challenges are as follows:

a. The project milestone has been determined by BATAN Leader, with a very tight schedule, including site evaluation and site permit that should be implemented in time manner. Time management is the key factor in measuring the success of the project.

b. Interaction between Site Team and Design Team (carried out by consultants and work in parallel) to determine the drilling point, need to be mutually agreed upon and interdependent of each other. This is a technical and management issue, and need an effective communication.

c. The location of the site had been determined to be located within the Science and Technological Research Park (PUSPIPTEK), therefore the option of locations is limited only on the vacant land available on Puspiptek. Several areas within PUSPIPTEK then proposed to the authority (Ministry of Research and Technology) to select one.

d. Considering that there has not been a comprehensive site study before in the study area that follows site evaluation standards and regulations, so that many sites evaluation items, installation of equipment for data acquisition, surveys for primary data collection and monitoring must be carried out in a short time.

e. There are still many different perceptions between the applicant (BATAN Team) and regulatory body (BAPETEN Team) regarding the site evaluation process both in substance and scope. The interaction between the applicant and the regulatory body is one of the key factors in the success of the site permit process.

f. BEPETEN regulations related to site evaluation have never been used before for the site permit process, and this evaluation process actually becomes a validation test for the implementation of regulations.

g. Management system of a complex project.

3. Objective
The purpose of this paper is to share experiences in managing site evaluation projects and its permit which are very complex processes, as a lesson learned in developing nuclear installation projects.

4. Methodology
The methodology used in this paper is to identify, study, analyze, and evaluate the empirical experience of each evaluation process and the licensing process so that it can be a valuable lesson in project management evaluation and licensing processes. This experience is very important as a feedback for the improvement of the system and the process of site permits and other permits in the developing of nuclear facilities, so that the licensing process can be managed properly and efficiently without reducing the safety factor.
5. Result and Discussion

5.1. Site Licensing Process

The site licensing process is divided into 2 phases. The first is Site Evaluation Program approval phases, where the applicant must submit 2 documents, namely site evaluation program (SEP) and management system of site evaluation (MSSE) [16]. Both documents then evaluated by BAPETEN until they are approved by Chairman of BAPETEN. The second phase is site permit process, where the applicant must submit a site evaluation report (SER) for all aspect, implementing report of MSSE, and a number of administrative documents. The process can be seen in Figure 1 and Figure 2.

![Diagram](image)

**Figure 1.** Approval process for site evaluation program (SEP)

SEP: Site Evaluation Program
MSSE: Management System of Site Evaluation

In practice, the SEP approval process takes a long time, from submitting documents until approval it was almost one year. The site evaluation program is crucial phase because it will determine the scopes and acceptance criteria that must be met and have an impact on the item and volume of site evaluation work and site acceptance. The process that takes a long time is caused by:

a. Both applicant and regulator are the first time to carried out a site permit, therefore in order to make a crucial decision regarding the critical issue, it take a long time and it usually delay a predetermined target.

b. Existing regulations are adopted from IAEA standards which are the requirements more suitable for larger commercial Nuclear Power rather than for experiment small scale nuclear power. The selected technology (high temperature reactor 10 MW) was also an obstacle from licensing process view because all this time the basis for regulation is light water nuclear power plants. Existing regulation is also not adopted graded approach yet. A long discussion regarding the acceptance criteria and scope of work also cause time to get longer.

c. During the discussion of the scope of the study, there were still differences in perceptions between the applicant and the regulator regarding the ultimate goal of site evaluation. Applicants assume that the purpose of site evaluation is to demonstrate site safety, but technical experts (TSO) from the regulator emphasize that the site evaluation objective is to provide data used for construction design. For example, for the geotechnical aspect, this difference of opinion causes the volume of work to be several times larger with regard to number and spacing of boreholes, drill depth, volume of in situ tests and lab tests, kind of in situ test, etc.
Lesson learnt:

a. Human resources who have technical competence and experience in site evaluation is really needed both for regulator and applicant.

b. Regulations need to accommodate the graded approach, including requirements and acceptance criteria, so that the evaluations carried out will not be excessive which will have consequences for longer completion times and higher costs.

c. Communication regarding the technology to be used must be delivered as earlier as possible.

d. It is needed a nuclear energy master plan, as a reference for regulator and applicant in preparing regulatory infrastructure.

e. It is also necessary to prepare TSO capability both to support applicant and regulatory body to improve quality of site evaluation.

For the second phase of site licensing process, Applicant should submit the administrative requirements first including proof of establishment of the applicant's legal entity, conformity to the spatial plan, proof of land rights, proof of site evaluation payment, site evaluation document (8 aspects), site evaluation system implementation document, reactor main data (RMD) and Preliminary Design Information Questionnaire (DIQ). This document was declared administratively complete on November 15, 2015. Furthermore, BAPETEN assessed and evaluated the technical documents submitted to determine the acceptability of the site. The process of evaluating the site evaluation document lasts quite a long and intensive. The meeting was held between BATAN and BAPETEN at the management level, the overall technical team and the special aspects technical team. Besides evaluating documents, field verification is also carried out. Finally, the site permit was issued on January 23, 2017.

![Diagram of Approval Process for Site Permit](chart.png)

**SER**: Site Evaluation Report  
**MSSE**: Management System of Site Evaluation  
**DIQ**: Design Information Questionnaire  
**RMD**: Reactor Main Data

**Figure 2. Approval Process for Site Permit**

On 13-18 December 2015 a technical evaluation of the findings (Preliminary Finding of BATAN Site Evaluation Report) has been conducted by IAEA through the PRE SEED (Site and External Events Design) Mission. As a follow up, BATAN improves by completing the data and analysis according to the evaluation results. Document revisions were made several times both after the plenary meeting and meeting of each specific aspect or issue. In addition, there is also a management level meeting to accelerate the site permit process. Field activities continue during the evaluation process and BAPETEN staff always monitor and inspect the field activities. Finally, the RDE site permit was granted through the Decree of the Head of BAPETEN Number 001 / IT / Ka-BAPETEN / 23-I / 2017. The process of
site permits from entering the application (27 October 2015) until the site permit issued takes 1 year 2 months. If the time is calculated from sending SEP and MSSE, the time needed to get a site permit is 2 years 10 months. If the preparation of the SEP and MSSE documents is calculated, it becomes 3 years and 4 months (from the target of 2 years). Time used for site permit can be seen at Figure 3.

![Figure 3. Time used for Site Permit](image)

**Lesson learnt:**

a. In the nuclear facility construction project cycle, the time to complete the site permit is too long, so that it will complicate the project implementation and disrupt the milestone. Regulators need to prepare technical guidelines for SEP especially the acceptance criteria that can be directly used by the user.

b. The parameters for site evaluation with the aim of site permit differ in terms of depth and density of the data with the site parameters required for construction design. In the process of site permits that have been carried out, this has not yet been distinguished, so that at the site evaluation stage for site permits it must meet the data completeness requirements for construction design. This resulted in prolonged discussions and site permits being delayed. Site permits should be more focused on in-depth study of site parameters that affect reactor safety.

5.2. Organization of Site Evaluation

Since the site evaluation work is very complex and the budget is limited, effective special organizations are needed [17]. The purpose of establishing this organization is to prepare all resources, technical documents, legal and cooperation frameworks, site evaluation activities, preparation of Design Information Questionnaire (DIQ) documents and Reactor Main Data (RMD) as well as other documents required in the site permit process.

After the SEP and the MSSE document have been approved by BAPETEN, field survey activities are carried out in accordance with a mutually agreed schedule. BATAN prepares a master schedule and detailed schedule for each aspect.

Considering that the technical scope is very broad and its competence is spread in several Technical Centers in BATAN and other Institutions outside BATAN, so for activities to be effective, a special organization needs to be formed with the top manager being the BATAN Chairman. Operational management is under the control of the Center for Nuclear Energy System Assessment, which manages and controls project operations. There are 7 Technical Centers and 1 Administrative Bureau in BATAN involved in site evaluation activities. Other institutions involved are the Geology Agency (technical centers: the Center for Geological Survey and the Center for Volcanology and Geological Disaster Mitigation), the Geospatial Information Agency (geospatial and GPS Geodetic data support), the Meteorology, Climatology and Geophysics Center (BMKG), University of Indonesia (hydrology), Bandung Institute of Technology (geotechnics), Gadjah Mada University (Geophysics). All experts and supporting staff involved more than 100 people. Some of the field work (mapping, geophysics) is contracted out to third parties with internal supervision carried out by experts in this particular organization and external supervision by BAPETEN.
MoU: Memorandum of Understanding
CA: Cooperation Agreement
CNESA: Center for Nuclear Energy Assessment

**Figure 4.** Organization of Site Evaluation [15]

To anticipate that work involving external institutions can run on time according to schedule and in accordance with the scope of work, project management instruments in the form of memorandum of understanding are needed between BATAN and the related Institution. Top management level in each institution will participate in monitoring the work carried out by experts under their authority.

**Lesson learnt:**
Site evaluation work involving many parties requires a very strong top management commitment, synergy both within BATAN and between institutions, intensive coordination, providing benefits for all parties involved, (especially in the development of research and competence), as well as strong, accountable and open administrative support. Strong commitment and communication must be built before the site evaluation begins

5.3. **Time Handling of Technical Aspects**
Considering many limitations (available existing data, human resources according to competency requirements, budget), normally, it will be difficult to meet the 2-year target from applying a SEP until a site permit. This is due to external factor dependence (BAPETEN) and interdependent work sequences. For this reason, it is required to perform a multi-level schedule consisting of the project milestone (overall RDE development plan), a master schedule for each site permit activity, a detailed schedule of each aspect and a detailed schedule of sub-activities in each aspect. The most difficult in controlling time is activities that involve external parties, related to synchronizing the implementation of activities that are at the same time with their internal activities. The agreed schedule is the key in controlling the activities.

During the survey activity there is a delay/hold point that gives BAPETEN an opportunity to evaluate the validity of the methods and data that have been taken. In this time delay period, the BATAN Team is not allowed to conduct survey activities. After being verified by BAPETEN, survey activities can be continued. In order the survey implementation not to be hampered by the result of BAPETEN inspection during the hold point, all method and standard operational procedure (SOP) have been well prepared and consulted with BAPETEN Technical Team. During site evaluation activities, BATAN has an internal quality assurance team that conducts internal audits, inspections, surveillance to ensure the quality of the site evaluation process. BAPETEN also periodically conducts external audits.
In practice, from submitting an SEP application to obtaining approval from BAPETEN, it takes one year. Discussion of items and work volumes as well acceptance criteria are the most critical factors and require a long period of time in discussion until they are mutually agreed upon. The lesson to be learned is that before submitting SEP, the acceptance criteria must be communicated first. Alternatively, BAPETEN already has acceptance criteria in their guidelines, as a reference for the preparation of the SEP.

For survey work that involves a lot of support staff, some of the work is done through contracts with consultants to save time. The consultant work based on the terms of reference (TOR) provided by BATAN. The TOR was prepared in detail by competent experts and discussed with BAPETEN in order to be in sync with the proposed SEP. The contracted work includes geological and volcanological mapping and geophysical work, where points and trajectories have been determined in the TOR. Data interpretation and analysis are not included in the contract, but are carried out by the Expert Team. In addition, drilling activities are also carried out by third parties.

The technical aspects that are crucial in managing time are as follows:

a. Seismic aspects, where the required data is very complex and its acceptance greatly affects the site feasibility results. Seismic analysis was compiled and based on regional geological maps, DEM, satellite imagery interpretation, verified structural data, paleoseismic, geodetic GPS, geophysical data interpretation (geoelectric, geomagnetic, georadar, seismic reflection, gravity), earthquake catalog, micro earthquake record (primary data), microzonation, stratigraphy, and seismotectonic models. Determination of wave propagation from bed rock to the surface is very dependent on the soil bedding model obtained from in situ testing during geotechnical drilling and microtremor survey [3] [4] [18].

b. Geotechnical aspects, especially for drilling planning. Prior to drilling, a topographic survey is carried out to provide a detailed topographic map with a scale of 1: 500 for the initial determination of the RDE layout planned by design consultants working in parallel. Determination of drilling points is carried out jointly between geotechnical experts and designers taking into account slope cross sections and potential geotechnical hazards (sinks, liquefaction obtained from geophysical surveys and some previous initial drilling points). This synchronization requires handling and management intervention, so that the planned drill points already represent the needs of foundation analysis and are in accordance with the conceptual design of RDE.

**Lesson learnt:**
- a. Internal progress review meeting is a management tools that to be done at least every two weeks
- b. Coordination with the RDE designer is required to be synchronized between site evaluation and RDE design activities.
- c. It is required a periodically communication and consultation with Regulatory Body and hold special meetings if there are problems that must be resolved immediately
- d. It is needed focusing on solving problems and following up on the Evaluation Results Report from Regulator Team.

**6. Conclusion**
The RDE site evaluation process is a very valuable experience in controlling a complex project with all its limitations, but is demanded by the target of time and budget. Site evaluation management requires a special organization that is able to control all activities effectively and can carry out effective communication both internally and externally, must be able to make careful and very detailed planning, able to control administration and finance. Effective communication with regulators is one of the keys factors to success in site evaluation until obtaining site permission.
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