Nuclear energy development self-management concept to support national energy security and national defense (case study: commercial NPP plans in the West Kalimantan region)

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Abstract. Indonesia's energy consumption is still increasing, including in the West Kalimantan Region, by 8.2\% growth in electricity customers. During this time, West Kalimantan still fulfilling its energy needs in imports around 30\% of energy supply (200 MW) from Sarawak, Malaysia. This condition can weaken national energy security and national sovereignty because it has not independently met its energy needs from domestic sources. At the same time, the potential for local energy sources in West Kalimantan is to get uranium deposits of 45,730 tons, which are nuclear fuel. Qualitative Analytical Hierarchy Process (AHP) research method to find the concept of self-management based on 4A (Availability, Affordability, Acceptability, Accessibility) + 1S (Sustainability). The results of the self-management concept obtained by integrating aspects: (1) Accessibility and Acceptability in the form of priorities for improving top-down and bottom-up cross-sectoral coordination management systems, namely the central and regional governments in the development of nuclear power plants with the involvement of local communities from the beginning of planning; (2) Affordability of making technical designs by BATAN with SMR (Small Modular Reactor) technology in the construction of commercial-scale nuclear power plants in terms of the availability of local resources as nuclear raw materials.

1. Introduction
Every country will secure the availability of long-term energy logistics supply to realize its energy security, including Indonesia through Sustainable Development Goals (SDG) for the use of clean and affordable energy as well as supporting environmentally-friendly climate change through the use of New and Renewable Energy sources (NRE) [1]. However, Indonesia’s energy conditions in realizing energy security have many challenges. For example, the still low utilization of NRE, which ranges from 8\% until March 2019 [2] from the target of achieving NRE of 23\% in 2025 as stated in Government Regulation (PP) No 79 of 2014 concerning National Energy Policy (KEN) [3].

One of the causes of the low utilization of NRE is due to the unfavourable strategic environmental conditions such as in the development of NRE for electricity generation, which are regulations that have not attracted investment, land and spatial issues, complicated licensing processes with long periods, not yet optimal energy capacity installed that is still limited by the availability of abundant energy sources, there is no incentive for the use of NRE [3]. Nuclear, as one of the new types of energy, has enormous potential for achieving NRE targets on a large scale. However, Government Regulations with Number
of 79/2014 on National Energy Policy states that nuclear energy is the last resort, but still provides a mandate for the 23% NRE target in 2025. And Presidential Decree (Perpres) with Number of 2/2015 on the National Medium-Term Development Plan (RPJMN) 2015-2019 to compile a roadmap and institutional development of a nuclear power plant for a 10 MW NPP pilot project [4]. The planning and preparation process for the construction of a nuclear power plant site in Indonesia began in the early 1970s. Various feasibility studies from the economic, technical, and environmental aspects of the development of nuclear power plants have been doing. Besides, several vital infrastructures have been prepared, including the establishment of the Nuclear Energy Supervisory Agency (BAPETEN) as an independent Supervisory Agency to carry out regulations, permits, and inspections. Implementing Agencies such as the National Nuclear Energy Agency (BATAN) tasked with carrying out nuclear utilization include the preparation of a nuclear science and technology base, Human Resources (HR) in the field of nuclear energy through education and research to meet the energy needs of Indonesia's NRE sources.

On the other hand, Indonesia's energy needs continue to increase, including in the West Kalimantan Region at 8.2% growth in electricity customers [5]. Energy needs for the household sector, transportation sector, industrial sector, commercial sector continue to increase from 541 MW in 2018 to 3,783 MW for 2027. During this time, West Kalimantan still meets its energy needs by importing around 30% of energy supply (200 MW) from Sarawak, Malaysia. Such conditions can weaken national energy security because they are not yet independent in meeting their energy needs from domestic sources. While the potential for local energy sources in West Kalimantan is getting uranium deposits amounting to 45,730 tons, which is a nuclear power plant fuel [6].

Indonesia, through Constitution with Number of 17/2007 the 3rd RPJM (2015-2019), has mandated the use of nuclear power for power plants by considering the safety factor closely and Presidential Decree with Number of 2/2015 regarding the 2015-2019 RPJMN for preparing the construction of nuclear power plants including increasing public revenue, which is one of the reasons the Indonesian government has not prioritized the construction of nuclear power plants [5]. Therefore, it is necessary to study the analysis of strategic decision making with the best choices and solutions to utilize nuclear energy so that the energy needs of the people in West Kalimantan can be met in supporting Indonesia’s energy security.

2. Method
The methodology used in this study includes collecting data and information from various libraries, journals, and other publications related to the preparation of the construction of nuclear power plants in Indonesia and analysed by the Analytical Hierarchy Process (AHP) method. AHP is a decision support method developed to solve problems by breaking down solutions to problems, grouping, and then arranging them into a hierarchical structure [9].

3. Results and Discussions

3.1. New and renewable energy development management system
The government regulates national energy management through Government Regulation with Number of 79/2014 concerning the National Energy Policy (KEN). The regulation has a vision and mission to develop energy security based on the dynamic 4A + 1S dimension, namely the availability dimension includes the availability of energy sources, such as fossil fuels, alternative energy, and renewable energy that comes from domestic and non-domestic, accessibility, namely the ability to access to energy sources, energy network infrastructure including geographic and geopolitical challenges to energy, affordability includes affordability of prices and energy costs from exploration, production and distribution to consumers, acceptability, which is acceptance of energy and sustainability including the use of sustainable and environmentally friendly energy sources which is depicted in Figure 1 [7]. KEN becomes the guideline and direction of national energy management to support sustainable national development.
In realizing optimal self-management of NRE development to realize energy security, it is necessary to have an NRE development management system, which is following the local potential of the local area, as shown in Figure 2 below. The energy management system includes: (a) Energy Planning (Plan), including the selection or determination of energy management objectives to be used, the determination of strategies for the plan (b) Implementation (Do) includes the preparation of a program consisting of the target program to be implemented, the strategy to be used, the organizational structure and personnel needed; (c) Monitoring and Evaluation (Check), including effective and efficient energy management activities, fostering awareness of each party developing NRE from potential resources in place; (d) Improvement and Adjustment (Action), consisting of priority grades of monitoring and treatment results, as well as monitoring and analysis of the implementation of fulfilling energy needs that are sufficient for areas that require energy. This management system will involve all components, including the government, the community, development investors, energy research institutions for the regions to be developed by NRE to support energy sustainability [8].

3.2. Nuclear energy development self-management concept

Self-management supports Indonesia's energy security, which is influenced by 4A aspects, namely Availability, Accessibility, Affordability, and Acceptability. That is the criterion used to guide the NPP development policy to be implementing. The availability criterion refers to increasing the utilization of nuclear energy reserves and resources. Accessibility criteria refer to increasing the supply of nuclear raw materials. Acceptability criteria refer to people's acceptance of the development of energy infrastructure; affordability refers to the efficient utilization of nuclear energy sources.

The first alternative is through improving the cross-sectoral bureaucratic coordination management system between the central and regional governments in the construction of nuclear power plants with the involvement of local communities since the beginning of the planning, process, and implementation.
of small-scale NPP (Small Modular Reactor) development. The second alternative option is to continue the implementation program of the NPP power reactor pilot project with the idea of an Experimental Power Reactor (RDE) as the forerunner to the Indonesian NPP. The third alternative option is to develop Indonesia’s domestic nuclear industry by the quality, codes, and standards of the nuclear power plants required for non-nuclear components so that they contribute actively to the development of nuclear power plants. Indonesia has great potential in supplying uranium raw materials.

The purpose of the analysis of strategic environmental decision-making with the criteria of Availability, Accessibility, Affordability, and Acceptability of the three alternatives is to recommend the best option in the construction of nuclear power plants to overcome the problem of equal distribution of electricity needs in West Kalimantan. The resulting alternatives are processed from the Analytical Hierarchy Process (AHP) method so that the best alternatives is obtained from the recommendations for analysing the strategic environment of the NPP development shown in Figure 3.

![Figure 3](image_url)

**Figure 3** The resulting alternatives are processed from the Analytical Hierarchy Process (AHP) method

The steps to determine the criteria weights and alternative validity of AHP analysis through (1) the stages of making pairwise comparison matrices (pairwise comparison matrices); (2) Determination of the main criteria in the form of priority vectors (priority vectors); (3) weighting based on a scale; (4) determination of maximum eigenvalues; (5) consistency index (CI), random generator value (RI) and consistency ratio (CR). The making of a pairwise comparison matrix for the criteria is shown in Table 1 and determining the main criteria in the form of priority vectors is in Table 2.

**Table 1** Creation of a pairwise comparison matrix for criteria

| Criteria       | Availability | Accessibility | Acceptability | Affordability |
|----------------|--------------|---------------|---------------|---------------|
| Availability   | 1.00         | 2.00          | 3.00          | 4.00          |
| Accessibility  | 0.50         | 1.00          | 2.00          | 3.00          |
| Acceptability  | 0.33         | 0.50          | 1.00          | 3.00          |
| Affordability  | 0.25         | 0.33          | 0.33          | 1.00          |
| Total          | 2.08         | 3.83          | 6.33          | 11.00         |

**Table 2** Determination of the main criteria in the form of priority vector

| Criteria       | Availability | Accessibility | Acceptability | Affordability | Total | Priority Vector | Product time | Product time/priority |
|----------------|--------------|---------------|---------------|---------------|-------|-----------------|--------------|----------------------|
| Availability   | 0.48         | 0.52          | 0.47          | 0.36          | 1.84  | 0.46            | 1.90         | 4.12                 |
| Accessibility  | 0.24         | 0.26          | 0.32          | 0.27          | 1.09  | 0.27            | 1.13         | 4.13                 |
| Acceptability  | 0.16         | 0.13          | 0.16          | 0.27          | 0.72  | 0.18            | 0.73         | 4.06                 |
| Affordability  | 0.12         | 0.09          | 0.05          | 0.09          | 0.35  | 0.09            | 0.35         | 4.03                 |
| Total          | 1.00         | 1.00          | 1.00          | 1.00          | 4.00  | 1.00            | Average= 4.09 | 1.00                 |
The criterion that becomes the main priority is availability because it has the most considerable priority vector value of 0.46. The maximum eigenvalue (maximum $\lambda$) is 4.09. The consistency index (CI) is around 0.03 and the random generator value (RI) for $n = 4$ is 0.89 (provisions of the Random Index table [9] as well the consistency ratio (CR) obtained is 0.03 (3%), so the response is relatively consistent because CR <10%. AHP Analysis Results from the three alternatives are shown in Table 3.

Table 3. Policy priority through weighting x criteria

| Policy option | Availability | Accessibility | Acceptability | Affordability | Total  |
|---------------|--------------|---------------|---------------|---------------|-------|
| Alternative 1 | 0.28         | 0.15          | 0.11          | 0.05          | 0.59  |
| Alternative 2 | 0.13         | 0.09          | 0.05          | 0.03          | 0.29  |
| Alternative 3 | 0.06         | 0.03          | 0.02          | 0.01          | 0.12  |

Thus, the main policy priorities are obtained by weighting multiplied by a criterion of 0.59 so that the selection of selected priority policies is improving the cross-sectorial bureaucratic coordination management system between the central and regional governments in the development of nuclear power plants with the involvement of local communities since the beginning of planning, process, and implementation, wrong only in West Kalimantan in the construction of a small-scale NPP (Small Modular Reactor).

The success of the NRE program will depend on the extent of regional political commitment (goodwill) supported by the central government, the private sector, and the community in the West Kalimantan Region. This commitment is expecting to be realized in the form of policies, comprehensive and integrated planning, and implementation, as well as program monitoring and evaluation consistently and responsibly (all-out) in the nuclear development sustainability plan in Figure 4.

Figure 4 NRE Development Self-Management Optimization Model

In Figure 4, showing in terms of availability, West Kalimantan has the potential availability of nuclear raw materials located in Ketapang Regency, Air Besar Village, Kendawangan District, Kendawangan Kanan Village, Kendawangan District, Sungai Kanan Village, Muara District, and Sungai Nanjung Village, District Matan Ketapang Regency, one location in Kayong Utara Regency in Sie Village, Simpang Hili District, and one location in Sambas Regency in Matang Village, Paloh District [10]. The Kalan location, West Kalimantan, is the only proven location with uranium content of 24-kilotons to meet the feasibility study [11,12]. In terms of affordability, Small Modular Reactors has a more affordable construction price, better passive SMR safety features, component designs are more straightforward, more compact, and flexible to be moved, even more easily produced by the domestic industry. The High-Temperature Gas-Cooled Reactor SMR type, which has mastered national technology, is already high with the launch of the PELUIT nuclear power plant design where technical design is made by BATAN, which requires a more affordable investment of around IDR 10 Trillion for 100 MWe power and IDR 13 Trillion for 210 MWe [11 ]. In terms of accessibility and acceptability,
due to the frequent conditions of power outages and the uneven fulfillment of electricity needs in West Kalimantan, some people consider nuclear options to bring prosperity to their electricity needs [12]. With a cross-sectoral bureaucratic coordination management system, it starts with a top-down management system where provincial and regional governments have a great interest in NPPs such as the Regional Planning and Planning Agency (Bappeda), which are potential stakeholders who have declared openness to prospective site studies and NPP plans. Bappeda is expected to bridge the social and security engineering needed if the NPP development plan in West Kalimantan has a positive indication. For the bottom-up management system, the community and universities are intensely conducting nuclear socialization such as Tanjungpura University (UNTAN) and the National Nuclear Youth Community (Kommun). UNTAN conducted socialization because of its great interest in technology and the spirit of regional progress. Besides UNTAN, other community groups are optimistic about nuclear energy development plans, namely the National Nuclear Youth Community (Kommun). Kommun is an independent nuclear activist community and has a passion for educating and socializing nuclear equally to the local community. Kommun's driving element is the local young generation (mostly students) who have a neutral image in the community, so it is hoped that the activities carried out are more trusted by the community. Since 2016 nuclear socialization activities have been initiated by UNTAN. In January 2017, UNTAN, together with the embryo of Kommun West Kalimantan Region, held a GO Bright seminar that contained nuclear and nuclear power plant socialization by inviting speakers from other agencies. In addition to the approach to community leaders who are still considered to be the Sultan's / Malay, the head of the tribe is also a practical approach for accepting the construction of the NPP by the local community. Therefore, it is only waiting for a decision from the central government to have the same support [10].

4. Conclusions
The concept of self-management of nuclear power plant development in West Kalimantan shows the concept of obtaining alternative policy priority decisions one to improve the cross-sectorial bureaucratic coordination management system between the central and regional governments in the development of nuclear power plants with the involvement of local communities since the beginning of planning, process, and implementation, one of them in West Kalimantan in development Small-scale nuclear power plant (Small Modular Reactor) to overcome energy scarcity for the achievement of national goals.

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