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Readiness of National Industries Infrastructure to Support the RDE Programme in Indonesia

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ABSTRACT

Nuclear Power Plant (PLTN) is one of the options to meet electricity for society and industry. BATAN has developed an Experimental Power Reactor (RDE) design which is one type of Non-Commercial Power Reactor (RDE) is a HTGR (High Temperature Gas-cooled Reactor) NPP with 10 MWth Pebble Bed Reactor (PBR) technology, and is used for non-electric electricity. This reactor type can generate electricity and heat. The development of RDE in Indonesia requires 19 aspects of nuclear infrastructure. One aspect of them is the involvement of national industries. The RDE development is expected to involve several national industries that can participate in supplying government goods and services. The purpose of this research is to determine the capability and readiness of the national industrial infrastructure to be able to participate in the development of RDE in Indonesia. The methodology used is literature review, technical surveys or visits, and technical consultations with key persons from industries. The study results conclude that the civil construction industries and the EPC industries have the readiness and ability to be able to build RDE building especially for non-nuclear parts. The Architect Engineering have the potential and capability for the RDE project management, engineering and Design development. The mechanical industries have the potential and capability to produce turbines, generators, condensers and heat exchangers. The electrical industries have the potential and capability to supply electrical components for the electrical system, such as Switchgear, main transformers, distribution transformers, generators, conductors, power cables, connectors and electrical panels. The Instrumentation & Control industries have the potency and capability to supply I&C products such as instrumentation cable, instrumentation communication system, temperature controller, etc. The output expected from this research is the readiness of nuclear infrastructure, especially the national industries for the supply of non-nuclear components.

INTRODUCTION

Indonesia as a developing country need of large amount of electricity. Many alternative energies that can be an option for the needs of this electrical energy. Nuclear energy is one alternative energy that can be used to meet the shortage of energy supply. Nuclear Power Plant (NPP) is an option for the use of short, medium- and long-term nuclear energy to support the economic and medium industrial growth in Indonesia. For supporting the NPP development, Indonesia have several regulation and government policies, including:

- Law number 10 of year 1997 concerning nuclear power: which carries out the mandate of regulations, institutions, businesses and aspects of NPP supervision in Indonesia [1].
- Government Regulation number 79 of year 2014 concerning National Energy

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Policies: to reduce carbon emissions and to meet the urgent national energy demand. Nuclear energy can be utilized as an energy supply under conditions that must be operated at a high level of safety and affordable prices[2].

This regulation will provide an opportunity to build the first NPP in Indonesia.

High-Temperature Gas-cooled Reactor (HTGR) technology was selected for the Next Generation Nuclear Power Plant (NGNP) project because it can supply electricity and high temperature which needed for industrial processes and the HTGR inherent safety features allows it to be coupled to industrial [3]–[10]. The vendors or industries such as Westinghouse, General Atomics, and AREVA, and were collaborated with the DOE to develop criteria and standards for main components required for the NGNP, including both electricity and hydrogen production [11], [12]. This HTGR design has benefit and the potency to do a cogeneration for the treatment of various minerals in various islands in Indonesia [13].

The HTGR is one of the small modular reactors and they are suitable for developing country [14]. HTGR is also one of Gen IV – nuclear reactors [12], [15]–[17]. HTGR will require reflector and a core design which can operate at extremely high temperatures for a long service life (~ 40 years) [18]. HTGR has a capacity of between 100 MWe to 300 MWe using uranium fuel, graphite moderator and helium gas as a cooler. HTGR operates at pressures of 100 atmospheres and temperatures up to 900ºC [19].

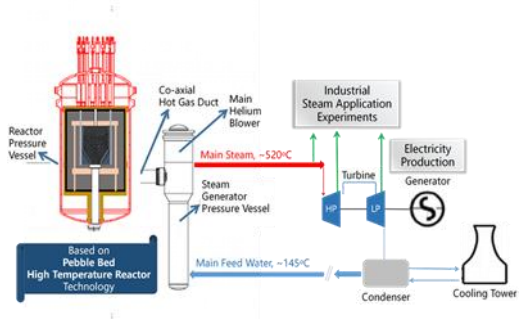

Fig. 1. Reaktor Daya Eksperimental (RDE) [20]–[22]

Based on the International Atomic Energy Agency (IAEA), there are 19 NPP infrastructure that must be prepared in the first NPP programme. One important aspect is the national industries involvement [23]. The Nuclear Infrastructure is very important for National Safety and Security [24].

BATAN as a research and development institution has conducted a study on RDE technology which is a type of nuclear reactor using High Temperature Gas Cooled Water Reactor (HTGR) technology with a type of Pebble Bed Reactor (PBR) powered by 10 MWth or 3 MWe. RDE Design adopted HTR 10 core type [25]. For supporting the National Industries involvement for NPP Development, BATAN refers to The Government Regulation of the Republic of Indonesia Number 14 of year 2015 concerning the 2015-2035 National Industrial Development Master Plan (RIPIN) which carries out the mandate to realize an independent, competitive, developed, and green industry as well as to realize national industries as pillars and drivers of the national economy. In the case of nuclear power plants, the determination of priority industries, especially in the field of nuclear energy, starting in the period 2020-2024 and the period 2025-2035 will be prioritized in the electrical equipment industry [26].

Development of Detailed Design RDE is a challenge for BATAN to continue to develop engineering design capabilities, specifically the design of nuclear reactor engineering, and pursue its ideals of becoming a Technology Provider in the field of nuclear energy in the near future[27].

For enhancing local content, this is very important to know the readiness of national industrial infrastructure that has the potency and capability to support and participate in RDE development. The first thing to do is to identify the capabilities and readiness of national industrial infrastructure based on their experience of being involved in large projects, especially those related to electricity generation.

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General scheme for RDE type can be showed at Figure 1. This scheme shows an RDE system which capable of producing electricity as well as cogeneration. RDE components consists of nuclear island and non-nuclear island components. The involvement of national industries is very important to increase the Level of Domestic Components (TKDN) or Local Content in the power plant development activities.

The Active role of national industries cannot be separated from how the government and stakeholders can implement and support the strategies to increase national industrial participation and technology transfer processes so that the Local Content (TKDN) becomes greater for participate in the RDE development [22], [28]. This is in accordance with Ministry of Industry regulations number 54/M-IND/PER/3/2012 concerning Guidelines for the Use of Local Products for Electricity Infrastructure Development [29].

National industries classification consists of 5 industries groups: civil construction industries, architect engineering industries, mechanical industries, instrumentation and control industries and electrical industries groups.

EXPERIMENTAL METHOD

The methodology is used for this paper from some literature study from national industries profile, survey of national industries or technical visit, and technical consultation with key persons. The International industries/NPP vendor is not included in this paper. The Result of data collection from survey and literature study were compared with RDE component classification, so that if they are suitable with the specification, this is the potency and capability of National industries. Flow chart of methodology can be showed at Figure 2.

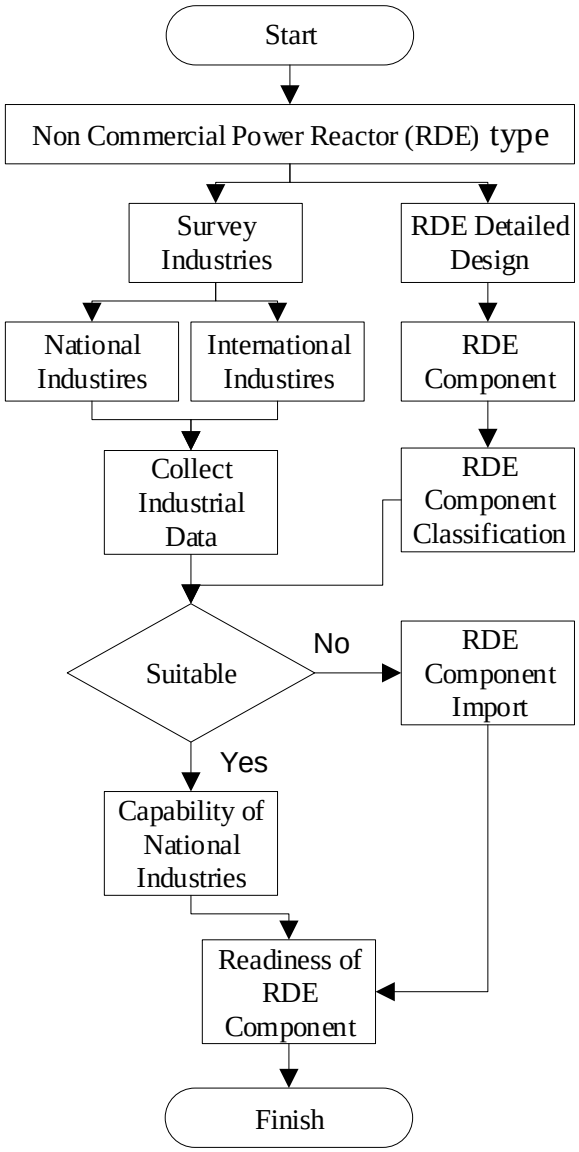

Fig. 2. Flow Chart of research methodology

RESULTS AND DISCUSSION

Civil Construction Industries

Civil construction industries are needed to build the NPP especially RDE in Indonesia. Some civil construction industries have some experience in the construction of conventional power plants, and there are also have experience in the construction of research reactors and nuclear irradiators. The civil construction industries and Engineering, Procurement, Construction (EPC) have ability to build RDE especially for the non-nuclear island section.

The Research reactor experiences was built Multi-Purpose Research Reactor of GA Siwabessy at PUSPTIPTEK, Serpong, Indonesia. Based on to the GA Siwabessy Multipurpose Reactor (RSG) construction, it is hoped that this experience can be applied and made a lesson for the nuclear power plant construction. The civil construction industries which have been involved in GA Siwabessy Reactor are the following [30], [31]:

a. Reactor building foundation work by PT. Hutama Karya
b. Civil works of the reactor building by PT. Waskita Karya
c. Detailed design for the operating building by PT. Architen
d. Civil works for the operations building by PT. Adhi Karya
e. Cooling tower installation by PT. Waskita Karya

The level of local content in the construction of the Siwabessy Multipurpose Reactor and its supporting laboratory is 35.7% consisting of civil construction and electrical - mechanical installations of 25.2%, equipment and infrastructure of 8.8% and engineering supervision of 1.7%. Nuclear power plant design and engineering capabilities have also been carried out by training personnel by following the Design Participation program in the vendor country (NPP technology owner).

In addition, BATAN as a research and development institution for nuclear technology has been entrusted with conducting Pipe Stress Analysis on the AP600 NPP system. Readiness in the management and Human Resources Development (HRD) must be continuously implemented and supported by its sustainability so that Human Resource (HR) is always ready at any time because after all HR will decrease over time so that new HR must be nurtured and prepared.

Table 1 show the component for Civil Work and some industries to support the civil construction programme.

Table 1. Civil Construction Work

No.	Component	Industry
1.	Civil work	PT. Waskita Karya
		PT. Hutama Karya
		PT. Adhi Karya
		PT. Nindya Karya
		PT. Pembangunan Perumahan
2.	Cement	PT. Semen Gresik
		PT. Semen Padang
		PT. Semen Tonasa
		PT. Semen Baturaja
		PT Holcim Indonesia
		PT. Semen Bosowa
		PT. Semen Kupang
3	Reinforced Steel and steel structure	PT. Krakatau Steel
		PT. Krakatau Wajatama
		PT. Krakatau Posco
		PT. Gunung Garuda
		PT. Gunawan Dian Jaya Steel
4.	Pile Material	PT WIKA Beton
		PT. Jaya Beton
		PPI
5.	Paint	Jotun
		SIGMA
		Hempel

Reinforced steel and steel structure material have the potency and capability to be used as steel structure for the construction of RDE in Indonesia because it uses ASTM A 572 and A 36 standards. Improvement and technology innovation are needed to fulfill the specified requirements for RDE.

Architect Engineering Industries

Architect Engineering industries can support the NPP for Design and engineering, project management and Engineering, Procurement and Construction (EPC). PT Rekayasa Engineering have experienced in the Feasibility Study and Design RDE. PT Rekayasa Engineering collaborated with NUKEM Jerman and PT Kogas Driyap Consultant to joint in RENUKO consultant for RDE Feasibility Study.

Table 2 show the national industries specially for design and engineering activities.

Table 2. Architect Engineering Industries

No	Main Product	Industries
1.	Design & engineering, project management	PT. Rekayasa Industri
2.	Architecture engineering, civil engineering, mechanical engineering, Eeectrical engineering, Environmental engineering	PT. Tripatra Engineers & Constructors
3.	Project Management, Procurement, Process System engineering	PT. Inti Karya Persada Tehnik (IKPT)
4.	Steel Structure, Mechanical, Electrical	PT. Truba Jaya Engineering
5.	Engineering, procurement and construction (EPC)	PT. Krakatau Engineering

Mechanical Manufacturing Industries

PT. Siemens Indonesia as one of the national industries in Indonesia has capability to manufacture and supply condenser, steam turbine, power transformer etc. One of the condensers components for supplying in the Olkiluoto NPP at Finland for the type of EPR (European Power Reactor) with a capacity of 1,600 MWe. PT Siemens has also manufactured the power plant components such as the outer and inner casing of a steam turbine with a large power capacity, generator casing and stationary blade range for the turbine. For Steam Turbine division of Siemens Indonesia's factory in Cilegon has become 100 percent owned by PT. Barata Indonesia. So that PT Barata Indonesia currently has capability to produce Turbines and Condensers. Steam turbines produced by PT Barata Indonesia have capacities ranging from 5 MWe to 1000 MWe. Chasing / turbine house, stator and blade can already be carried out by PT Barata Indonesia, but specifically for rotor manufacturing, until now PT Barata has not been able to produce so it must be imported from abroad, namely from Stork Turbo Netherlands. While the biggest condenser ever made is for Olkiloto NPP in Finland with a capacity of 1600 MWe.

PT. Barata Indonesia already has the latest roll plate machine with a thickness of 200 mm, so that nuclear vessels can be made by Barata even up to 1600 MW capacity can already be made. Until now the thickness of the plate made is up to 120 mm according to the order. With a thickness of 200 mm, the vessel is capable of making up to a pressure of 250 bar [32].

PT. Boma Bisma Indra has experience of the ability and potential to supply components of non-nuclear island parts especially for the manufacture of pressure vessels, condensers, high pressure heater, low pressure heater, deaerator, heat exchangers and circle water piping for conventional power plants. This capability can be enhanced step by step to supply components of pressure vessels by providing stringent requirements for the use of standard pressure vessels for nuclear reactors. This capability can be enhanced by having investments to purchase equipment facilities that support the manufacture of nuclear scale pressure vessels that are supported by nuclear codes and standards. Pressure vessel products for power plants (Kamojang), (Mount Salak, wayang Windu, and Lahendong with capacity more than 50 MWe). Heat exchangers capacity more than 50 MWe (Paiton, Suralaya, Gresik, Muara Karang, Asam Asam. Condenser with capacity 400 – 1000 MWe was total manufactured 65 unit for domestic and export to Asia, Eropa, Australia, Amerika and Africa. High Pressure Heater for Paiton unit 1, 2, 7, 8, and 9, Tambak Lorok and Suralaya unit 2. Low Pressure Heater was export to Malaysia and Taiwan. Feed Water Storage Tank and Deaerator was exported to Australia, Oman, Vietnam, UEA, and Singapore. For Mechanical design, PT. BBI use Compress Design Software/Codeware for Pressure Vessel Design, AMETank and API standards for Ground Storage Tank Design, Structural analysis use Staad Pro Tool, Finite element Stress Analysis use ANSYS, Inventor, SolidWorks, Fabrication Drawing use AutoCAD 2D and 3D, etc [33].

Table 3. PT. PAL Indonesia Manufacturing [34]

No.	Year	Manufacturing & Contractor
1.	1987	Manufacturing Balance of Plant Coal Fire Power Plant Suralaya Unit 3 & 4 (2x400MW) PT Indonesia Power
2.	1993	Manufacturing Balance of Plant and ST/GT Gresik Combine Cycle Power Plant 3x500MW Mitsubishi Heavy Industry
3.	1996	Assembly Steam turbine Tj Priok,PT Indonesia Power (2x50MW) Manufacturing Balance of Plant
4.	1997	Manufacturing Exhaust Casing ST Combined Cycle Power Plant 400MW – Tenaska Pakistan General Electric
5.	1998	Manufacturing Exhaust Casing ST: 1. Coal Fired Power Plant 600MW Turkey Mitsubishi Heavy Industry 2. Coal Fired Power Plant 400MW – Thailand General Electric
6.	1999	Manufacturing 90 Unit Stator Frame 300 to 700MW General Electric
7.	2000	Manufacturing 10 Unit Stator Frame 300 to 600MW Harbine Turbine-China
8.	2001	Manufacturing Condenser Coal Fired Power Plant 600MW Tachibana Wan & Hirono – Japan Mitsubishi Heavy Industry
9.	2008	Manufacturing Balance Of Plant Coal Fired Power Plant 600MW El Tebbin – Egypt Alstom Power System
10.	2009	Manufacturing LP & HP Casing Turbine 1000 MW Nuclear Power Plant Flamanville – France Alstom Power System
11.	2012	Retubing HP Feed Water Heater 6 unit 5 Suralaya 600 MW (Ex Unit 1) PT Indonesia Power Retubing HP Heater 7 Unit 6 Suralaya 600 MW (Ex Unit 2) PT Indonesia Power
12.	2017	Reverse Engineering & Manufacturing : 1. HPH No.1 Unit 1 PLTU Labuan 2x300 MW 2. HPH No.2 Unit 2 PLTU Pelabuhan Ratu 2X350 MW 3. HE C3W No. 2 Unit 1 PLTU Lontar 3 3x315 MW PT Indonesia Power
13.	2018	Root Cause Failure Analysis & Retubing Condenser, PLTU Suralaya Unit 8 2x625 MW PT Indonesia Power
13.	2019	Reverse Engineering & Manufacturing: 1. HPH No. 6 ex Unit 7 UP Suralaya 600 MW 2. HE C3W (1 Unit) UP PLTU Banten 2 Labuan (2x300 MW)

PT. PINDAD has produced generators with a total production of more than 200 units with a capacity of 0.8 MW to 4.5 MW which are intended for Diesel Power Plants. PT PINDAD has also fabricated synchronous generator for Kamojang geothermal power plant with capacity 3 MW, stator generator for hydro power plants with capacity 11.8 MW (reverse engineering), and synchronous generator for Coal Power Plant with small scale with capacity 8.5 MW (in manufacturing process) [35].

PT. Nusantara Turbin & Propulsi (PT. NTP) is one of turbine industries in Indonesia. PT. NTP fabricate and produce steam turbine and gas turbine, and they collaborate with Badan Pengkajian dan Penerapan Teknologi (BPPT)/Technology Research and Application Body to make prototype steam turbines up to 7 MWe. Turbine from PT. NTP has been tested and obtained a proper operation certificate for 3 MWe Geothermal Power Plant where the turbine has a low pressure and temperature of 6.5 bar, and 185ºC. The next time, PT NTP in collaboration with BPPT will conduct 4 MWe testing program for biomass [36].

PT. PAL Indonesia have supported electricity program 35.000 MWe to Indonesian Government. This industry has experiences to manufacture some power plant components for export especially in ASEAN region. For nuclear power plant, PT. PAL have corporate and joint venture with Thorcorn International Pte, Ltd, Nuclear Power Plant for design Thorium Molten Salt Reactor Power Plant 500

MWe to support PT. PLN for New Energy availability.

PT. PAL have any experiences to fabricate conventional power plant component especially for steam turbine with capacity until 1000 MWe. For export, PT. PAL have manufactured LP & HP Casing Turbine 1000 MW for Nuclear Power Plant Flamanville, France. Table 3 show some experiences PT. PAL's manufacturing.

Electrical Industries

The electrical industry has the potential and ability to supply electrical components to electricity systems. Such as Gas Insulated Switchgear, main transformer, distribution transformer, generator, conductor, electrical cable, connector and electric panel. The electrical industry that can supply electrical components is PT. ABB Sakti Industri, PT Trafoindo Perkasa Tbk, PT. Kabelindo Murni, PT UNINDO, PT. Sucaco and others. The use of international and national quality standards for national industrial products can increase local content in the construction of the First NPP in Indonesia.

PT. Bambang Djaya (B&D) is one of national industries which produces many different types of transformers including power transformer, distribution transformer, mobile transformer, single phase and three phase transformers, ranging from 15 kVA up to 500 MVA with voltage ratings up to 275 kV. They have successfully become the first "purely own Indonesian" company to manufacture 150 kV Power Transformers. The company plans to continue growing further, and is now in full development for ratings up to 500 kV [37]. **Table 4** show the Electrical industries with their products.

Tabel 4. Electrical Industries

No.	Component	Industry
1.	Main Transformer	PT. ABB Sakti Industri
		PT. UNINDO
		PT. Trafoindo Prima Perkasa
		PT. Bambang Djaya
		PT. Siemens
2.	Distribution Transformer	PT. Bambang Djaya
		PT. Trafoindo Prima Perkasa
		PT. UNINDO
3	Switchgear	PT. ABB Sakti Industri
		PT. UNINDO
		PT. Cilegon Fabrocator
		PT. Basuki Pratama Engineering
4.	Switchyard control panel	PT. UNINDO
		PT. Panelindo Makmur Sentosa
		PT. Schneider Indonesia
		PT. Industira
5	Power Cable Class 1E	PT. Kabelindo Murni
		PT. BICC Berca Cables
		PT. Sucaco
		PT. Voksel Electric Tbk

Instrumentation and Control Industries

Instrumentation & Control components consist of flow indicator, safety pressure cut out for high pressure protection, instrumentation cable, speed rotor Indicator (Transmitter), instrumentation communication system, reactor protection system, speed rotor indicator, flow indicating controller, etc. **Table 5** show instrumentation and control industries.

Readiness for national industries such as PT. Barata Indonesia, PT. Siemens Indonesia, PT. Boma Bisma Indra, PT. PINDAD, PT. PAL Indonesia has the potential and capability to produce turbines, generators, condensers and heat exchangers. and also produces several types of components for nuclear power plants with a capacity of 3 MWe.

Table 5. Instrumentation & Control Industries with their products

No.	Component	Industry
1.	Flow indicator (Transmitter	PT Arita Prima Indonesia
		PT. Maju Mapan Mandiri Indah Pratama
2.	Flow Indicating Controller	PT Yokogawa Indonesia
		PT Budijaya Makmur Ssentosa
		PT Arita Prima Indonesia
3	safety pressure cut out for high pressure protection	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT Yokogawa Indonesia
		PT. Harapan Utama Indonesia
4.	Speed rotor Indicator (Transmiter)	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT Yokogawa Indonesia
		PT. Mitreka Citra Tama
5	Temperature Controller	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT Yokogawa Indonesia
		PT. Hikmah Jaya Sentosa
6.	Reactor Protection system	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT Yokogawa Indonesia
7.	Instrumentation cable	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT Yokogawa Indonesia
8.	Instrumentation Comunication System	PT. Harapan Utama Indonesia
		PT. Maju Mapan Mandiri Indah Pratama
9.	Emergency Control Room	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT. Hikmah Jaya Sentosa
10.	Centre Control Room	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT Yokogawa Indonesia
11.	CCTV system	PT. Maju Mapan Mandiri Indah Pratama
		PT. Harapan Utama Indonesia
		PT. Wingel Instrumen Indonesia
12.	Distributed Control System (PLC)	PT. Maju Mapan Mandiri Indah Pratama
		PT Arita Prima Indonesia
		PT. Mitreka Citra Tama

CONCLUSION

The civil construction industries and the EPC industries have the readiness and ability to be able to build RDE building especially for non-nuclear parts. The Architect Engineering have the potential and capability for the RDE project management, engineering and Design development. The mechanical industries have the potential and capability to produce turbines, generators, condensers and heat exchangers. The electrical industries have the potency and capability to supply electrical components for the electrical system, such as Switchgear, main transformers, distribution transformers, generators, conductors, power cables, connectors and electrical panels. The Instrumentation & Control industries have the potential and capability to supply I&C products. National industries infrastructure is ready to support and participate the First Nuclear Power Plant in Indonesia for with capacity 3 MWe.

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