DEVELOPMENT OF INDONESIA’S NUCLEAR FUEL CYCLE ROADMAP
OUTLINE

1. Introduction
2. Overview of Fuel Cycle Activities in Indonesia
3. Development of Fuel Cycle Roadmap
4. Fuel Programme for Non-Commercial Power Reactor Project
5. Fuel Fabrication Planning for Commercial Power Reactor Project
6. Summary
1. INTRODUCTION

- R&D of nuclear fuel cycle technology in Indonesia comprises front end (mining & milling, conversion, fuel fabrication) and back end (spent fuel and waste management) to support deployment of NPPs in Indonesia.

- Projection of commercial NPPs deployment in the 2014 Indonesia’s Nuclear Energy Outlook (INEO) indicates deployment of commercial large reactors starting from 2027 and SMRs from 2037. A decision has also recently been taken to construct power reactor for non-commercial use (I-EPR) to be commissioned by 2020.

- Fuel programme is prepared to account for deployment of both commercial power reactors and non-commercial power reactor within the given timeframe.

- It is viewed that a fuel cycle roadmap needs to be developed.

- A roadmap team has been assembled to develop the fuel cycle roadmap in the 2015-2016 cycle. The activity benefits from participation of Indonesia in INPRO Collaborative Project ROADMAPS.
2. OVERVIEW OF FUEL CYCLE ACTIVITIES IN INDONESIA
Nuclear Fuel Technology Programme

R&D of fuel for research reactor and power reactor
- Prototype of U-Mo and U-Zr based fuel for research reactor
- Powder-based LWR fuels, advanced particle-based LWR & HTGR fuel
- Modelling for PRTF fuel pin and cermet-based fuel

Production of MTR fuel for research reactor
- Previously developed U$_3$Si$_2$-Al fuel to replace U$_3$O$_8$-Al

Irradiation in research reactor

Fuelling
- G.A.Siwapessy Research Reactor

Storage of MTR spent fuel

Experimental Fuel Element Installation: Conversion and Fuel Fabrication

Post-Irradiation Examination

Installation of Radiometallurgy
3. DEVELOPMENT OF FUEL CYCLE ROADMAP

• **Objective**: To develop a fuel cycle roadmap depicting national nuclear energy policies, possible scenarios to achieve the targets, milestones of fuel cycle facilities development, assessment of sustainability of the scenarios, identification of necessity for R&D and pursuance of regional/multilateral collaboration.

• **Duration**: 2015-2016

• Sustainability of Indonesia’s nuclear fuel cycle should be part of a larger or global picture that embraces the heterogeneity in the world and how countries can collaborate with one another.

• The roadmap should identify strategies for its nuclear power program including options for innovative nuclear fuel cycle.
Status of Fuel Cycle Roadmap Development

- Development of template
- Scenario for reactor technology based on technology assessment and national policy
- To include thorium after 2040

Proposed Roadmap Template
- Introduction
- Objective
- Scope
- Assumptions
- Methodology
- Role of nuclear energy in national energy mix
- Status of reactor technology in the world
- Status of nuclear fuel cycle
  - Mining and milling
  - Conversion
  - Enrichment
  - Fabrication
  - Spent Fuel Management
- Strategy of nuclear fuel cycle 2025-2050 in Indonesia
- International Collaboration
- Strategy of nuclear fuel cycle 2050-2100 in Indonesia
4. FUEL FABRICATION PLANNING FOR NON-COMMERCIAL POWER REACTOR

TECHNOLOGY READINESS LEVELS (TRLs)

- **NFE**
  - Design, simulation, material analysis, facility set up (lab)
  - PTBBN, PTRKN, PSTBM

- **NFE-PIE**
  - Synthesis, Fabrication, Pre-irradiation test
  - PIE preparation
  - Pilot plant set up
  - PTBBN, PRSG, PTRKN

- **PROTOTYPES**
  - Post-irradiation licensing
  - PTBBN, PRSG, PTRKN, PTLR, Abroad

- **CTDs**
  - 1 Basic Principles Observed and Reported
  - 2 Technology Concept and/or Application Formulated
  - 3 Active R&D Proof of Concept
  - 4 Component Validation in Laboratory Environment
  - 5 Component Validation in Operational Environment
  - 6 Prototype Demonstration in Relevant Environment
  - 7 System Prototype in Operational Environment
  - 8 System Qualified through Test and Demonstration
  - 9 System Qualified through Mission Operations

DSTO

2015-2019

Industry Adoption

2019-2023

2023-
FUEL PROGRAMME FOR NON-COMMERCIAL POWER REACTOR PROJECT

R&D Facility for Capacity Building

- Procurement of equipment, process, materials, QA&QC
- Trainings for personnel
- R&D on HTGR fuel technology
- Human resources development

Fuel Industry

- Plant and Licensing from fuel vendor
- Produce fuel for Indonesia’s experimental power reactor
- Construction of fuel production plant in reactor complex in Serpong

International Cooperation

- To establish close cooperation for capacity building
- Funding
  - Regular budget
  - Extra budgetary
  - Others

Universities and Technical Institutes – Master and doctoral programme

BATAN’s Education and Training Center

- To establish close cooperation to obtain skilled personnel
Roadmap of Fuel Programme for Non-Commercial Power Reactor Project

HTGR Fuel R&D Programme for Capacity Building

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<tr>
<td>Establishment of equipment, process, materials, QA&amp;QC in BATAN laboratory in Yogyakarta</td>
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<td>Qualification of fuel production: Fabrication, Irradiation Testing, Post Irradiation Examination, Evaluation, Design</td>
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<td>Development of human resources: Cooperation with educational institutes and Training of industry personnel</td>
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HTGR Fuel Industry Programme

| Site licensing and Plant licensing |
| Building Installation and Engineering Procurement Construction for HTGR fuel production plant in Serpong |
| Cold and hot commissioning |
| Fuel Qualification |
| Fuel production |
| Human resources |

Fuel Loading in Reactor

| Purchase of several fuel loads |
| Domestic fuel loading |
Lab scale developed prior to 2014 will serve as knowledge base to set up engineering scale facility within the period 2015-2019 to supply fuel for the non-commercial power reactor project.

<table>
<thead>
<tr>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tr>
<td>Gel UO₂/ADU</td>
<td>UO₂ kernel fabrication</td>
<td>UO₂ (TRISO) kernel coating equipment</td>
<td>TRISO fuel compacting equipment</td>
<td>Qualification for irradiation</td>
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<td>Fabrication equip</td>
<td>equipment</td>
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Fuel Value Chain Strategy for Non-Commercial Power Reactor Project

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<tr>
<th>Activity Type</th>
<th>National Capability</th>
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<tr>
<td>Raw Materials</td>
<td>Uranium Resource</td>
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<tr>
<td>Primary Production</td>
<td>Conversion yellow cake to UO2 (pilot Scale)</td>
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<tr>
<td>Processing</td>
<td>Uranium pellet, plat/pin fuel element, kernel (lab. Scale)</td>
</tr>
<tr>
<td>PIE</td>
<td>Under preparation (PRTF)</td>
</tr>
<tr>
<td>Nuclear Fuel</td>
<td>U-Si (low density)</td>
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5. FUEL FABRICATION PLANNING FOR COMMERCIAL POWER REACTOR PROJECT

TECHNOLOGY READINESS LEVELS (TRLs)

- High Risk for Product Launch
- Low Risk for Product Launch

**NFE Design, Simulation, Material Testing**
PTBBN, PTRKN, PSTBM

**CTDs**

1. Basic Principles Observed and Reported
2. Technology Concept and/or Application Formulated
3. Active R&D Proof of Concept
4. Component Validation in Laboratory Environment
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**Prototypes**
NFE Post-irradiation Bundling licensing PTBBN, PRSG, PTRKN, PTLR

**Production**

**DSTO**
2015-2018

**Industry Adoption**
2018-2030

2030-
Overview of Fuel Activities for Fuel Commercial Power Reactor Project

- Indonesia has a pilot plant facility for HWR fuel production and a post-irradiation examination hot cells facility.
- The pilot plant facility is currently also used for R&D of fuel for power reactors.
- In line with plan for deployment of PWR type reactor, qualification of short pin is being performed: Fabrication, Irradiation and Post irradiation examination, as well as Computer simulation.
- Indonesia also performs R&D on zirconium-based alloy.
UO₂ Fuel Production
6. SUMMARY

✓ Development of nuclear fuel cycle roadmap is being undertaken depicting national nuclear energy policies, possible scenarios, milestones of fuel cycle facilities development, assessment of sustainability of the scenarios, identification of necessity for R&D and pursuance of regional/multilateral collaboration.

✓ Roadmap for development of fuel production capability for non-commercial power reactor project has been prepared, to be updated as necessary

✓ Preparation of qualified short pin of PWR fuel type is done to support deployment of commercial power reactors
THANK YOU