Application of the INPRO Roadmap template with respect to Thailand nuclear energy program

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- Nuclear energy as part of Thailand energy mix
- Nuclear energy scenario and strategy
- Options for technological innovations and expansion of international cooperation for enhanced Nuclear Energy sustainability for Thailand
Nuclear energy as part of a national energy mix
National long-term social and economic objectives of sustainable development

Country Strategic Positioning
- Thailand as a high income country
- Trading and Service Nation
- Sustainable Agricultural Products Producer
- Creative and Eco-friendly Industrial Destination

Human Resources as center of integrated development

Infrastructure Development

Economy

Sustainable Agricultural Development

(Draft)
The Twelfth National Economic and Social Development Master Plan (2017 - 2021)

TARGET / OBJECTIVES
- Agriculture to food industry development
- Strengthen citizen welfare and Promote Capacity Building Development
- Reducing inequality of social welfare
- Overall country development with environmental conservation to achieve sustainable development goal
- Integration of Regional Development
Energy strategies compatible with long-term sustainable development of the country

National Energy Strategies

Integration of all Energy Development Plan

Security  Economy  Ecology

PDP  EEP  AEDP  Gas  Oil

Integrated Regulation Scheme

1) Security
- Diversification of fuel mix
- Reduce dependency on natural gas

2) Economy
- Power Tariff that reflects the true cost of electricity services
- Fairly determined Power Tariff to consumers and power utilities

3) Ecology
- Increase RE proportion from 8% to 20%
- Reduce CO2 Emission from 0.506 to 0.319 kgCO2/kWh in 2036

Energy Efficiency Plan

PDP2015 (2015 - 2036)

Alternative Energy Development Plan
Motivation for nuclear power development

- High dependency on natural gas for power generation at 64% in 2014
- Reduce power generation cost by introducing new power sources such as Nuclear Power
- Commitment on environmental conservation by reducing the use of fossil fuel

Utilization of Nuclear Power in PDP2015

- Introducing two nuclear power plants with total installed capacity of 2,000 MW in 2036
- Nuclear Energy as non-fossil fuel for power generation
Nuclear energy scenario and strategy for Thailand
Nuclear Energy Infrastructure Devolvement Program (Tentative plan according to PDP 2015)

- Milestone 1: Ready to make a Knowledgeable commitment to a nuclear programme
- Milestone 2: Ready to invite bids for the first NPP
- Milestone 3: Ready to commission and operate the first NPP

**Infrastructures Development Program**

**Phase 1**: Consideration before a decision to launch a nuclear power programme is taken

**Phase 2**: Preparatory work for the construction of an NPP after a policy decision has been taken

**Phase 3**: Activities to implement a first NPP

**Phase 4**: Maintenance and continuous Infrastructure improvement

- 1st NPP Project

- Pre-project
  - Feasibility study
  - Project decision making
  - Construction
    - Commissioning
    - Operation / decommissioning

- Tentative Plan
  - 2007: 100% @ 12/2010
  - 2017: Thailand
  - 2020: Pre-project
  - 2026: 1st NPP Project
  - 2029: Tentative Plan
  - 2035: Previous Plan

- Previous Plan
  - 2007: 100% @ 12/2010
  - 2017: Thailand
  - 2020: Pre-project
  - 2026: 1st NPP Project
  - 2029: Tentative Plan
  - 2035: Previous Plan
Status of Thailand Nuclear Power Program

Until 2011

- **Readiness report** is already prepared and waiting for cabinet approval.
- Review of the **Status of the National Nuclear Infrastructure** in Thailand has been done and the final report has been submitted to the Ministry of Energy on May 18, 2011.
- **Most works in phase 1** have been **completed** following the IAEA guidelines.

2012- present

- Revision of **plan on Thai Nuclear Power Program**, specially in the following areas:
  - **Siting selection criteria**,  
  - **Social** and environmental **impact**
  - **Nuclear power plant safety**

Information in this slide based on the presentation slide in Technical meeting on topical issue in the development of nuclear power infrastructure at IAEA, 4-7 Feb 2015 by Supapol Ratanakorn, EGAT, Thailand
Current Challenges

- National position
  - Government policy & details of process and timeframe the government will make a decision
- Public acceptance,
  - promote understanding and participation for Public
- Infrastructure Preparation
  - Related Laws and regulations
  - Human resource development
  - Independent nuclear regulatory

Information in this slide based on the presentation slide in Technical meeting on topical issue in the development of nuclear power infrastructure at IAEA, 4-7 Feb 2015 by Supapol Ratanakorn, EGAT, Thailand
Vision on National prospects for nuclear energy size and growth and the role of NES collaboration strategy

- **Small** nuclear energy growth (below 0.1 and 0.5 GW$_e$/year) during 2016-35
- Nuclear Energy Size of $2 \times 1,000$ MWe is planned to produce electricity by 2036
- From 2036 to 2100, no official power development plan for Thailand is launched yet.
Vision on National prospects for nuclear energy size and growth and the role of NES collaboration strategy (cont’d)

- NES collaboration strategy **would mainly** base on **International cooperation**: single bi-lateral agreement during 2016-2055

- International cooperation: **multiple bi-lateral agreements (buying technology from more than one countries)** would also be considered during 2056-2100

- **Only Storing of SNF** may have a possibility to rely on national indigenous technology development with an option of international cooperation until end of the century.

- NPP Operation could be in the framework of **international cooperation** (single bi-lateral agreement) at the **short-term time** frame and national indigenous technology development at the mid- and long-term timeframe.

- The above information is gathered from our **expert opinions**.
Experiences on Spent Nuclear Fuel (SNF) Management for Thai Research Reactor

- SNF of 1.2 MW research reactor TRIGA type
- Shipping SNF from Thailand back to US
- Spent nuclear fuel storage building at reactor site
- Development of the national policy and strategy for radioactive waste and SNF management

Information in this slide based on the presentation slide in 10th INPRO DF at IAEA, 26-29 May 2015 by Nanthawan Ya-anant, TINT, Thailand
Options for technological innovations and expansion of international cooperation
Options for technological innovations and expansion of international cooperation

- Base nuclear energy option (PWR or BWR) is considered during all time frames.
- To enhance nuclear energy sustainability of Thailand, safe disposal of spent nuclear fuel is required for the time frame of 2056-2100.
- Higher reactor outlet temperatures can be an option, e.g. HTGR, for future technologies for Thailand.
- At this stage, the closed fuel cycle is not considered yet.
However, if other technologies are proved to be safe, economical, and eco-friendly, we absolutely reconsider them as options.

Expansion of international cooperation, e.g. nuclear waste management, reactor safety, is our interest for public acceptance.
Conclusions

- **PDP 2015**: $2 \times 1000 \text{ MWe}$ by 2036 in Thailand
- **Current challenges** on national position, public acceptance, infrastructure preparation
- **Single bi-lateral agreement** would be the main collaborative strategy in the short- and mid-term time frames.
- **Multiple bi-lateral agreements** and national technology development would be considered for NPP operation and SNF storage in a longer time frame.
- **Technology innovation and international cooperation** would focus on PWRs and BWRs and SNF disposal.
  - **Future technologies (open cycle)** would be also considered in a longer time frame.
Backup slides
Table 1a: National prospects for nuclear energy size and growth until the end of the century
Please, try to fill out boxes for National prospects for nuclear energy size and growth for time frames
as: X = yes,
Please, identify whether the information provided as: (a): official plan, (b): scenario study or expert opinion

<table>
<thead>
<tr>
<th>Nuclear energy growth taking into account a decommissioning</th>
<th>Current</th>
<th>Time frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the information provided (a) an official plan or (b) a scenario study or expert opinion</td>
<td></td>
<td>2016-2035</td>
</tr>
<tr>
<td>Decreasing Stabilization including replacement of units</td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>Small growth (below 0.1 GWe/year)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Medium growth (between 0.1 and 0.5 GWe/year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant growth (&gt;0.5 GWe/year)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Nuclear energy size</th>
<th>Current</th>
<th>Time frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>No nuclear</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Small (0-10 GWe)</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Medium (10-50 GWe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (&gt;50 GWe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1b: National prospects for NES collaboration strategy until the end of the century
Please, try to fill out boxes for NES collaboration strategy for time frames as: (1) National indigenous technology development, (2) International cooperation: single bi-lateral agreement, (3) Multi-lateral agreement, (4) International cooperation: multiple bi-lateral agreements/ multiple suppliers providing for a competitive choice of the supplier/customer

If more than one strategy applies for a box put all the applicable numbers in the box
If nothing apply, please, leave box blank

Please, identify whether the information provided is: (a) official plan, (b) a scenario study or expert opinion

<table>
<thead>
<tr>
<th>Please, indicate your country:</th>
<th>Time frames</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
</tr>
<tr>
<td>Is the information provided (a) an official plan or (b) a scenario study or expert opinion</td>
<td>b</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>NES collaboration strategy</th>
<th>NES Function</th>
<th>Time frames</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>2016-2035</td>
</tr>
<tr>
<td>Obtain/produce Uranium</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Convert/enrich uranium</td>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>Fabricate/obtain fuel</td>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>Produce Energy</td>
<td>NPP design</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>NPP operation</td>
<td>(2)</td>
</tr>
<tr>
<td>Store SNF</td>
<td>(1),(2)</td>
<td>(1),(2)</td>
</tr>
<tr>
<td>Reprocess SNF</td>
<td>(1),(2)</td>
<td>(1),(2)</td>
</tr>
<tr>
<td>Dispose HLW/SNF</td>
<td>(1),(2)</td>
<td>(1),(2)</td>
</tr>
</tbody>
</table>

Note: (1) = National indigenous technology development, (2) = International cooperation: single bi-lateral agreement, (3) = Multi-lateral agreement, (4) = International cooperation: multiple bi-lateral agreements/ multiple suppliers providing for a competitive choice of the supplier/customer.
Table 2: Technology options of interest to your country to enhance Nuclear Energy sustainability
Please, put X in the box when the option applies. Leave the box blank, if the technology does not apply. More than one X per column is allowed.

<table>
<thead>
<tr>
<th>Group</th>
<th>Option</th>
<th>Time frames</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current</td>
</tr>
<tr>
<td>Technology</td>
<td>A Base nuclear energy option</td>
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</tr>
<tr>
<td></td>
<td>B Safe disposal of spent nuclear fuel</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>C Higher reactor outlet temperatures to open new energy markets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D Once-through breed and burn</td>
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<tr>
<td></td>
<td>E Limited recycling of used nuclear fuel to reduce waste</td>
<td></td>
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<tr>
<td></td>
<td>F Fast breeder reactors (BR&gt; 1) and a closed fuel cycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G Minor actinide transmutation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H Thorium-based closed fuel cycle</td>
<td></td>
</tr>
</tbody>
</table>