Status of Nuclear Power Development in Thailand

Dr. Kamol Takabut
Assistant Governor - Power Plant Engineering
Electricity Generating Authority of Thailand (EGAT)

Lunch Talk, Thai French Technical Association
Pan Pacific Hotel, Bangkok, August 26, 2010

Nuclear Power and National Energy Plan

  On June 4, 2007
  4x1,000-MWe NPP in 2020 (2 units) and 2021 (2 units)

- Cabinet approved Revision 2 of PDP 2007
  On March 24, 2009
  2x1,000-MWe NPP in 2020 (1 unit) and 2021 (1 unit)

- Cabinet approved New PDP 2010 (2010 – 2030)
  On March 30, 2010
  5 NPP units (2020, 2021, 2024, 2025, 2028)
Electricity Generation 2009
(Based on type of fuel)

Total Electricity Generation
145,233 GWh

Natural Gas
71.8%

Total Installed Capacity 29,213 MW

Source: Electrical Generating Authority of Thailand

PDP 2010 Thailand Fuel Mix for Power Generation

MW Nuclear power option Included in PDP

Nuclear
Diesel
Renewable Energy
Heavy Oil
Power Import
Natural Gas
Imported Coal
Lignite
Hydro

Slide no. 4
## Thailand fuel Mix for Power Generation

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<thead>
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<th>Year</th>
<th>NG</th>
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<th>NPP</th>
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### Alternatives Energy Options

- Geothermal Energy
- Wind Power
- Biomass Power Plant
- Nuclear Power Plant
- Solar Power Plant
- Mini-Hydroelectric
WTG 150 kWe from 1966 to 2001 at Leam Promthep, Phuket

Electricity Generation

= 195,000-210,000 kWh

= 1,300 -1,400 kWh/kW

Plant Factor 15-17 %

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Remark
Installed/Start in July 1996

Electricity Generation

= 195,000-210,000 kWh

= 1,300 -1,400 kWh/kW

Plant Factor 15-17 %

I = 14 MB, I = 5 %,
n = 20 y, O&M = 1.5 B/kWh

Gen Cost, U = 8 B/kWh

Wind Turbine Generator at Lamtaklong Dam
Capacity 2.5 MWe  Investment Cost 165 million Baht
Phabong Maehongsorn Solar Power
Capacity 504 kW (COD April 9, 2004)

- Average Generation: 700,000 kWh/y
- Average Generation: 1,309 kWh/kWp/year
- Generation Cost: 14 Baht/kWh

Site

1,000 kWp Sirindhorn Solar Cell Power Plant

Grid connected: November 30, 2009
Fang Geothermal Area

- 150 Km. NW of Chiang Mai
- TGWG and French Agency AFME carried out the exploration
- 3 shallow wells, depth less than 90 m, discharge hot water 120°C, total amount of 21 l/s
- The 300 kWe Binary Cycle Power Plant is implemented and started to commercial operation and connected to PEA Grid since December 5, 1989

Fang Geothermal Binary Cycle Power Plant

Plant Installed Capacity 300 kW

Annual Generation 1.8 – 2 M kWh, Average Gen Cost 3 – 4 B/kWh
Connected to PEA Grid, Selling Cost 2 B/kWh
Nuclear Energy

Chain Reaction

Control

439 NPPs in operation 30 countries and 57 Under Construction

Source: Reactor data: WNA - 3/6/10
### World Nuclear Power Reactors & Uranium Requirements

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**Note:** Data as of 3/18/10

**Source:** World Nuclear News, January 2010.
**Thermal Power Plant**

1. Fuel
   - (Oil / Gas / Coal)

2. Steam Generation Part

**Nuclear Power Plant**

1. Nuclear Fuel
   - Uranium / Plutonium

2. Electricity Generation Part

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**Boiling water reactor, BWR**

1. Containment Structure
2. Reactor Vessel
3. Control Rods
4. Steam
5. Generator
6. Feed Water
7. Condenser
8. Cooling Water

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Pressurized water reactor, PWR

Fuel Rod

Fuel Price 1 kg (UO₂) USD 1,770 (Nov 2006 USD)
Generation 360,000 kWh = 0.49 c/kWh (0.20 B/kWh)
Nuclear Fuel Utilization

Each LWR Fuel Rod contains about 500 kg of Uranium

Spent Fuel will recycle as follows

- Recycle by Enrichment Process
- Recycle and recover Plutonium Process to be MOX Fuel
- Fission products & minor actinides: 15 to 20 kg (3-4%)

Electricity Generation
form 1 kg of Fuel

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<td>Enriched Uranium 3 - 4%</td>
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Source: NEI, IAEA
Source: Projected Costs of Generating Electricity: 2005 Update, IEA/NEA.

Assumptions:
- Economic lifetime of 40 years for most plants
- Average load factor for base-load plants of 85%
- Discount rates of 5% and 10%
- Costs exclude transmission and distribution costs

\[ U = \frac{I + O&M + F}{G} \]
### Cabinet Approved

On October 30, 2007 and December 18, 2007

- Nuclear Power Infrastructure Establishment Plan (NPIEP)
- Setup of Nuclear Power Program Development Office (NPPDO)
- Appointment of Nuclear Power Infrastructure Establishment Cooperation Committee (NPIECC)
- Implementation plan and budget for pre-project activities (2008-2010)
- Public education and participation program

#### Organization

```
Prime Minister

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<th>Ministry of Science and Technology</th>
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NEPIO (2011)
Nuclear Power Infrastructure Establishment Cooperation Committee

appointed on December 26, 2007

NPIECC Comprises 5 sub-committees (SC):

SC1. Legal System, Regulatory System and International Protocols
SC2. Nuclear Power Utility Planning
SC3. Industrial Infrastructure, Technology Transfer, Technology Development, and Human Resources Development
SC4. Nuclear Safety and Environmental Protection
SC5. Public Information and National Participation Program
SC 6 Readiness Report Preparation is created to finalize the Readiness Report (19 items of IAEA) within November 2010.
Infrastructural Development Programme

Milestone 1 — Ready to make a knowledgeable commitment to a nuclear programme

- NEPIO established and staffed
- Safety, security and non-proliferation needs recognized
- Appropriate international legal instruments identified
- Comprehensive legal framework identified
- Establishment of effectively independent regulatory body recognized
- Nuclear power included in nation’s development strategy
- Needs of project management identified
- Human resources needs surveyed
- Financial resources evaluated
- Arrangements for handling and storage of radioactive waste identified
- Supply of national and international components and services assessed
- Transparent communication and interaction regarding the nuclear programme established

Issues

1. National position
2. Nuclear safety
3. Management
4. Funding and financing
5. Legislative framework
6. Safeguards
7. Regulatory framework
8. Radiation protection
9. Electrical grid
10. Human resources development
11. Stakeholder involvement
12. Site and supporting facilities
13. Environmental protection
14. Emergency planning
15. Security and physical protection
16. Nuclear fuel cycle
17. Radioactive waste
18. Industrial involvement
19. Procurement

IAEA NUCLEAR ENERGY SERIES No. NG-G-3.1
VIENNA, 2007
Nuclear Power Project Schedule

Preliminary Phase 1 year 2007
Pre-Project Activities Phase 3 years 2008-2010

GO NUCLEAR! – Government to approve the project

Project Implementation Phase 3 years 2011-2013
Construction Phase 6 years 2014-2019
Commercial Operation 2020

Utility Preparation
For Pre-Project Activities Phase (2008-2010)

- Electricity Generating Authority of Thailand (EGAT) is responsible for the first nuclear power station under the supervision of Nuclear Power Utility Sub-Committee
  - planning, feasibility study, site selection, project implementation, construction and operation

- EGAT is currently conducting Nuclear Power Plant Feasibility Study

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Nuclear Power Plant Feasibility Study

1. Energy Economics and Financing
   - National Energy Market Analysis
   - Electric System Analysis
   - Choice of Unit Size
   - Nuclear Cost Estimates
   - Generation Cost
   - Funding Review

2. Technical and Safety Aspects of Nuclear Power
   - Technical Aspects
   - Safety Aspects
   - Security and Safeguards

3. Fuel Cycle and Waste Management

4. Reactor Technology, Reactor Supplier and Fuel Supplier Selection

5. Site and Environmental Study
   - STEP 1 – Identification of Candidate Sites
   - STEP 2 – Evaluation of Candidate Sites

6. Human Resources Development and Management Aspects
   - Human Resources Development Plan
   - Project Development
   - Legal Framework and licensing process
   - Public Information and National Participation
### Work Progress

**Nuclear Power Plant Feasibility Study**

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*Note: % complete is measured in terms of budgeted cost of work.*

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### Site Survey Challenge

- Having difficulties accessing some potential sites due to local community opposition caused by:
  - Bad experience on past industrial development projects
    - Pollution, Corruption, Unfair Compensation
  - Concerns on public safety (radiation leak and past nuclear accidents), possible contamination on agricultural and fishing products, and possible decrease in number of tourists
    - Lack of basic understanding on radiation and nuclear power
Other Challenging Issues

- Political instability
- Public education and acceptance
- Human resources development
- Laws and regulations for nuclear power
- Capability of nuclear regulatory body

Manpower Distribution Single Unit Site (All Phases)

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<td>8</td>
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<td>Total Manpower</td>
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<td>67</td>
<td>121</td>
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Training Plan 2010-2013

<table>
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<tr>
<td>Fundamentals of Nuclear Power</td>
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<td></td>
</tr>
<tr>
<td>General Training</td>
</tr>
<tr>
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</tr>
<tr>
<td>Functional Training for Construction &amp; Operation Management</td>
</tr>
<tr>
<td></td>
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</table>

Local education and Training
- Chulalongkorn U. (GNPP, Diploma, Master, and Ph.D in nuclear engineering)

Overseas education and Training for Health Physics, Nuclear and Reactor Engineering, Nuclear Chemistry, Radiation Engineering
- Universities in US, France, Japan, Korea, China

NPP Vendors via EPC Contract for functional operation
- Operators and Maintenance Staffs

International Consultants/Organizations/Agencies/NPP Utilities/EGAT’s partners for functional EPC
Recruitment of personnel to support the project (existing and new)

Partnering with other NPP utilities and organizations

Sending project personnel e.g. project manager, group leaders, plant engineer, project controls, construction engineer, materials procurement to other ongoing NPP sites (construction and operation) for OJT

Set up the scholarships in the critical areas e.g. Health Physics, Nuclear and Reactor Engineering, Nuclear Chemistry, Radiation Engineering

Establishment of in-house training centre

---

Public Opinion Poll

<table>
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<tr>
<th>Nuclear Power Development</th>
<th>Agreed</th>
<th>Disagreed</th>
<th>Not Specified</th>
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<tbody>
<tr>
<td>In Thailand</td>
<td>64%</td>
<td>32%</td>
<td>9%</td>
</tr>
<tr>
<td>In their province</td>
<td>32%</td>
<td>59%</td>
<td>9%</td>
</tr>
<tr>
<td>In their communities</td>
<td>24%</td>
<td>66%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Note: The survey was conducted in 2009
Public Communication

- Public Opinion Survey
- Preparation/distribution of PR tools
  - Printed Media
    - Nuclear News Magazine
    - Booklet and Leaflet
  - Website
- PR activities utilizing mass media
- Seminars on Nuclear Power

Expected Assistance from Vendor Countries and Others

- **Training**: specific and on-the-job training programs for utility and regulatory body
- **Sharing technical experience**: project implementation, construction, operation and maintenance, regulation, decommissioning, waste management
- **Guiding**: public communication and hearing
<table>
<thead>
<tr>
<th>IAEA’s 19 Issues</th>
<th>Responsible for Milestone 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sub-Committee</td>
</tr>
<tr>
<td>1. National position</td>
<td>SC 1-5</td>
</tr>
<tr>
<td>2. Nuclear Safety</td>
<td>SC1, 2, 4</td>
</tr>
<tr>
<td>3. Management</td>
<td>SC2</td>
</tr>
<tr>
<td>4. Funding and financing</td>
<td>SC2</td>
</tr>
<tr>
<td>5. Legislative framework</td>
<td>SC1</td>
</tr>
<tr>
<td>6. Safeguards</td>
<td>SC1, 2, 4</td>
</tr>
<tr>
<td>7. Regulatory framework</td>
<td>SC1, 2</td>
</tr>
<tr>
<td>8. Radiation Protection</td>
<td>SC1, 2, 4</td>
</tr>
<tr>
<td>9. Electrical grid</td>
<td>SC2</td>
</tr>
<tr>
<td>10. Human resources development</td>
<td>SC1-5</td>
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</table>

National Strategy and Strategic Plans for the Development of Infrastructure for Nuclear Power
Organization Responsible for Readiness Report Preparation (IAEA’s 19 issues)

<table>
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<th>IAEA’s 19 Issues</th>
<th>Responsible for Milestone 1</th>
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<tbody>
<tr>
<td></td>
<td>Sub-Committee</td>
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<tr>
<td>11. Stakeholder involvement</td>
<td>SC 5</td>
</tr>
<tr>
<td>12. Site and supporting Facilities</td>
<td>SC 2</td>
</tr>
<tr>
<td>13. Environmental protection</td>
<td>SC 4</td>
</tr>
<tr>
<td>14. Emergency planning</td>
<td>SC1, 2, 4</td>
</tr>
<tr>
<td>15. Security and physical Protection</td>
<td>SC1, 2</td>
</tr>
<tr>
<td>16. Nuclear fuel cycle</td>
<td>SC1, 2</td>
</tr>
<tr>
<td>17. Radioactive waste</td>
<td>SC1, 2</td>
</tr>
<tr>
<td>18. Industrial involvement</td>
<td>SC 3</td>
</tr>
<tr>
<td>19. Procurement</td>
<td>SC 2</td>
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</table>
### 1. National Position

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Safety, security and safeguard committed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2 The NEPIO established and staffed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 National strategy defined</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 2. Nuclear Safety

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Key elements of nuclear safety understood</td>
<td></td>
</tr>
<tr>
<td>2.2 Need for intergovernmental instruments on safety recognized</td>
<td></td>
</tr>
<tr>
<td>2.3 Support through international cooperation intended</td>
<td></td>
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</table>

#### 3. Management

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Energy strategy and nuclear power compatibility analyzed</td>
<td></td>
</tr>
<tr>
<td>3.2 Unique Member State conditions evaluated</td>
<td></td>
</tr>
<tr>
<td>3.3 Available nuclear technologies identified</td>
<td></td>
</tr>
<tr>
<td>3.4 Ownership options and operational responsibilities considered</td>
<td></td>
</tr>
<tr>
<td>3.5 Authorities and responsibilities established</td>
<td></td>
</tr>
<tr>
<td>3.6 Appropriate expertise and experience involved</td>
<td></td>
</tr>
<tr>
<td>3.7 Commitment to management systems that promote and support a strong safety culture, evident</td>
<td></td>
</tr>
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</table>

### 4. Funding and Financing

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Adequate funding for the NEPIO provided</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2 Strategies for funding and financing established</td>
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### 5. Legislative Framework

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Adherence to all relevant international legal instruments planned</td>
<td></td>
</tr>
<tr>
<td>5.2 Plans for development of national nuclear power legislation in place</td>
<td></td>
</tr>
<tr>
<td>5.3 Consultation with national stakeholders about the legislative framework taken place</td>
<td></td>
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### 6. Safeguards

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Obligations under NPT and non-proliferation treaties and other international instruments, recognized</td>
<td></td>
</tr>
<tr>
<td>6.2 Development, implementation and enforcement of safeguards framework, including SSAC establishment, planned</td>
<td></td>
</tr>
<tr>
<td>6.3 International requirements for any existing nuclear facilities or locations outside facilities met</td>
<td></td>
</tr>
</tbody>
</table>

### Significant Actions Needed

- [ ] Significant Actions Needed
- [ ] Minor Actions Needed
- [ ] No Actions Needed
## Conclusion of IAEA’s 19 Issues Meeting (cont)

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>IAEA</th>
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<tbody>
<tr>
<td><strong>7. Regulatory Framework</strong></td>
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</tr>
<tr>
<td>Conditions</td>
<td>Status</td>
</tr>
<tr>
<td>7.1 Development of an adequate regulatory framework planned</td>
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</tr>
<tr>
<td><strong>8. Radiation Protection</strong></td>
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</tr>
<tr>
<td>Conditions</td>
<td>Status</td>
</tr>
<tr>
<td>8.1 Hazards presented by NPP operation recognized</td>
<td></td>
</tr>
<tr>
<td>Enhancements to national regulations and infrastructures planned</td>
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<tr>
<td><strong>9. Electrical Grid</strong></td>
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<td>Conditions</td>
<td>Status</td>
</tr>
<tr>
<td>9.1 Electrical grid requirements considered</td>
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<td><strong>10. Human Resources</strong></td>
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<td>Conditions</td>
<td>Status</td>
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<tr>
<td>10.1 Necessary knowledge and skills identified</td>
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</tr>
<tr>
<td>Develop and maintenance of human resource base planned</td>
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<td><strong>11. Stakeholder Involvement</strong></td>
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<tr>
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<tr>
<td>11.1 Strong public information and education programme initiated</td>
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<tr>
<td>Need for open and timely interaction and communication regarding the nuclear power programme addressed</td>
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<td></td>
<td>Significant Actions Needed</td>
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<td><strong>12. Site and supporting facilities</strong></td>
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<td>Conditions</td>
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<td>12.1 General survey of potential sites, conducted</td>
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<tr>
<td>12.2 Selected sites justified</td>
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<td><strong>13. Environmental Protection</strong></td>
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<tr>
<td>Conditions</td>
<td>Status</td>
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<tr>
<td>13.1 Unique environmental issues recognized</td>
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<tr>
<td>13.2 Environmental impact assessment production and communication recognised</td>
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</tr>
<tr>
<td>13.3 An effective environmental framework for existing uses of radiation sources in place</td>
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<tr>
<td><strong>14. Emergency Planning</strong></td>
<td></td>
</tr>
<tr>
<td>Conditions</td>
<td>Status</td>
</tr>
<tr>
<td>14.1 Appreciation of the need for emergency planning developed</td>
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<tr>
<td>14.2 Communication with and involvement of local and national government taken into account</td>
<td></td>
</tr>
<tr>
<td>14.3 Emergency planning for existing radiation facilities and practices in place</td>
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<tr>
<td><strong>15. Security</strong></td>
<td></td>
</tr>
<tr>
<td>Conditions</td>
<td>Status</td>
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<tr>
<td>15.1 Necessary regulations identified</td>
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<tr>
<td>15.2 Effective security protection for existing uses of radiation sources in place</td>
<td></td>
</tr>
<tr>
<td>15.3 Necessary regulations identified</td>
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<td>Significant Actions Needed</td>
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Conclusion of IAEA’s 19 Issues Meeting (cont)

<table>
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<tr>
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<th>IAEA</th>
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<td>16.1</td>
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<td>16.2</td>
<td>Need for on-site spent fuel storage recognized</td>
<td>Status</td>
<td>Status</td>
</tr>
<tr>
<td>16.3</td>
<td>Interim spent fuel storage considered</td>
<td>Status</td>
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<th>IAEA</th>
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<td>Knowledge of nuclear fuel cycle steps and approaches developed</td>
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<td>Status</td>
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<tr>
<td>17.2</td>
<td>Need for on-site spent fuel storage recognized</td>
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<td>Status</td>
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<tr>
<td>17.3</td>
<td>Interim spent fuel storage considered</td>
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<table>
<thead>
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<th>Industrial Involvement</th>
<th>Phase I</th>
<th>IAEA</th>
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<tr>
<td>18.1</td>
<td>National policy with respect to national and local industrial involvement considered</td>
<td>Status</td>
<td>Status</td>
</tr>
<tr>
<td>18.2</td>
<td>Need for strict application of quality programs for nuclear equipment and services recognized</td>
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</table>

<table>
<thead>
<tr>
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<th>Procurement</th>
<th>Phase I</th>
<th>IAEA</th>
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<tbody>
<tr>
<td>19.1</td>
<td>Unique requirements associated with purchasing nuclear equipment and services recognized</td>
<td>Status</td>
<td>Status</td>
</tr>
<tr>
<td>19.2</td>
<td>Consistent policies for nuclear procurement in place</td>
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<td>Status</td>
</tr>
</tbody>
</table>

Significant Actions Needed ▪ Minor Actions Needed ▪ No Actions Needed

Conclusion of the discussion

General comments

1. The report is well prepared but some important aspects are required to be reviewed.
2. There is a lot of work that has been done.
3. There are suggestions from IAEA that need to improve the report.

Improving the report

1. General introduction must include a brief history of each item, how to perform the report, who participates, how to get the information, etc.
3. Put the time frame of each planning.
4. End of each sub-element should explain how to make a decision: Red / Yellow / Green.

General comments on 19 items

1. Red should include Legal Aspect, Regulatory System, Safety, Safeguard & Security and Legislative Framework.
2. Some items declared yellow should be green:
   - Grid system, HRD (but need to make for the country not only EGAT),
   - Management & Procurement.

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## Time Line of the Readiness Report Preparation

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<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
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<tbody>
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<td>1. Preparation of Draft Report of all 5 SCs</td>
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<tr>
<td>2. Completion of Final Report of all 5 SCs</td>
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<td></td>
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<tr>
<td>3. Draft Readiness Report of Thailand Nuclear Power Plant Establishment</td>
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<td></td>
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<tr>
<td>4. IAEA Experts Meeting</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5. NPIECC Consideration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. IAEA Experts Meeting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Final Readiness Report</td>
<td></td>
<td></td>
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<tr>
<td>8. NEPC Consideration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NEPC : National Energy Policy Council  
NPIECC : Nuclear Power Infrastructure Establishment Coordinating Committee  

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Thank you for your attention

Virtual view of the new unit 3 of Flamanville