THE SPENT FUEL STORAGE AND TRANSPORTATION OF CHINA——CHALLENGES AND RECOMMENDATIONS

China General Nuclear Power Corporation
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Content

01. Demand of Spent Fuel Storage and Transportation

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1. Nuclear Power Situation of China

Mid & Long-term nuclear development plan of China: In year 2020, nuclear capacity in operation will be 58 GW, under construction will be 30 GW. This date will grow to 90GW and 30-40 GW in year 2025, and grow to 120GW in year 2030.
2. Demand of Spent Fuel Storage and Transport

### Storage and Transport Demand of China

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual production/t</th>
<th>Accumulating production/t</th>
<th>Annual AFR /t</th>
<th>Accumulating AFR /t</th>
<th>Annual transfer/t</th>
<th>Accumulating transfer/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>665</td>
<td>3522</td>
<td>200</td>
<td>600</td>
<td>188</td>
<td>456</td>
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<tr>
<td>2020</td>
<td>1298</td>
<td>8718</td>
<td>319</td>
<td>2023</td>
<td>262</td>
<td>1594</td>
</tr>
<tr>
<td>2025</td>
<td>1923</td>
<td>16764</td>
<td>876</td>
<td>5236</td>
<td>819</td>
<td>4522</td>
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<tr>
<td>2030</td>
<td>2637</td>
<td>28285</td>
<td>1605</td>
<td>11559</td>
<td>1503</td>
<td>10560</td>
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</table>

**Note:**
1) Calculated base: In year 2015, nuclear power capacity in operation is 46GW. In year 2020, capacity in operation is 58GW, under construction is 30GW. In year 2030, capacity in operation is 120GW.
2) Spent fuel will be transferred away from reactor pool after cooling 8 years.
3) Qinshan 3th and Sanmin Fast Reactor are not included.
4) SF transport of Qinshan 1st and Tianwan Reactor are not included.
2. Demand of Spent Fuel Storage and Transport

Storage and Transport Demand of China

The spent fuel production, away-from-reactor and transport demand have a step growth.
2. Demand of Spent Fuel Storage and Transport

**Significant Growth of CGN SF transfer demand**

- As originally planned, beginning in Year 2016, SNF demanded to be transferred away from Daya Bay is 3~4 times of current number.
- In Year 2018, SNF pool newly built in 404 will reach its own storage limit, if no other interim storage solutions or storage location is developed, Reactor 1 & 2 of Daya Bay will face the danger that there is no storage slot for newly unloaded SNF.

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<tbody>
<tr>
<td>Daya Bay</td>
<td>1#</td>
<td>78(Trans)</td>
<td>52</td>
<td>26</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>104</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>2#</td>
<td>26(Trans)</td>
<td>52</td>
<td>78</td>
<td>78</td>
<td>26</td>
<td>78</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Lingao I</td>
<td>1#</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>78</td>
<td>52</td>
<td>78</td>
<td>52</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>2#</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>52</td>
<td>78</td>
<td>52</td>
<td>78</td>
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<tr>
<td>Lingao II</td>
<td>1#</td>
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<td></td>
<td></td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>2#</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Every year</td>
<td>104</td>
<td>104</td>
<td>104</td>
<td>286</td>
<td>234</td>
<td>286</td>
<td>338</td>
<td>338</td>
<td>338</td>
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<tr>
<td>Added</td>
<td>208</td>
<td>312</td>
<td>598</td>
<td></td>
<td>832</td>
<td>1118</td>
<td>1456</td>
<td>1794</td>
<td></td>
</tr>
</tbody>
</table>
2. Demand of Spent Fuel Storage and Transport

**CGN higher burn-up SNF out-transfer demand**

- Beginning from 2016, the SNF to be transferred away from Daya Bay will be of burn-up higher than 45000 MWd/tU, which also undergoes cooling time less than 8 years in SNF pool.
- In another word, the burn-up and cooling parameters of SNF to be transferred away is over the authorized limit of the current containers.

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<tr>
<td>Initial enrichment (%)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤4.45</td>
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<tr>
<td>Cooling time (year)</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>&lt;8</td>
<td>&lt;8</td>
<td>&lt;8</td>
<td>&lt;8</td>
<td>&lt;8</td>
<td>&lt;8</td>
</tr>
<tr>
<td>Burn-up (MWD/TU)</td>
<td>&lt;45000</td>
<td>&gt;45000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cooling time (year)</td>
<td>9</td>
<td>9, 8</td>
<td>9, 8</td>
<td>&lt;8</td>
<td>&lt;8</td>
<td>&lt;8</td>
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<td>&lt;8</td>
<td>&lt;8</td>
<td>&lt;8</td>
</tr>
<tr>
<td>Burn-up (MWD/TU)</td>
<td></td>
<td>&gt;45000</td>
<td></td>
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</tbody>
</table>
01. Demand of Spent Fuel Storage and Transportation

02. Situation and Challenges of Spent Fuel Storage and Transportation

03. Suggestions
1 Situation of Spent Fuel Storage and Transport

Transport capacity is limited. Transportation capability buildup is linked to many issues, such as container, transport method, route, time window, etc. It is a system engineering.

Limited transport capacity

- **Limited transport capacity**
  - 2 containers ONLY for AFA-3G FA.
  - Subjected to weather conditions, like snow, frost and typhoon. Average capacity now is twice a year, or 104 FAs per year.

- **Limited transport methods, Long distance, High risk**
  - Road transport ONLY.
  - ~3000 km, ~3 months one way.
  - high risk

- **Disadvantage in cost**
  ——International transport cost is 50-70 dollars/kgHM; (dates from OECD, BCG reports)
  ——Domestic transport cost is 180 dollars/kgHM.

- **Vulnerable to big social events**
  - Such as vital meeting and festival, during which time, SNF transport experienced disturbance in the past.
  - High social concern
### Situation of Spent Fuel Storage and Transport

Currently, 2 ways to store the SF in China: 1) In SF pool in reactors; 2) In SF pool in 404 Facility. Latter is the only facility for spent fuel interim storage.

- **Single mode and insufficient storage capacity**

<table>
<thead>
<tr>
<th>SF pool</th>
<th>Capacity (t)</th>
<th>hack</th>
<th>B1</th>
<th>B2</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daya Bay</td>
<td>500</td>
<td>864</td>
<td>432</td>
<td>432</td>
<td>Full</td>
</tr>
<tr>
<td>Qinshan 1st</td>
<td>216</td>
<td>108</td>
<td>108</td>
<td></td>
<td>Reserved, not received</td>
</tr>
<tr>
<td>404 Expanded Pool</td>
<td>800</td>
<td></td>
<td>(400T)</td>
<td>(400T)</td>
<td>Operating time unknown</td>
</tr>
</tbody>
</table>
1 Situation of Spent Fuel Storage and Transport

Currently, 2 ways to store the SF in China: 1) In SF pool in reactors; 2) In SF pool in 404 Facility. Latter is the only facility for spent fuel interim storage.

Single mode and insufficient storage capacity

Nation’s SNFs need to be transferred away from stations

Where to transfer and store the SNF in 2018?
1 Situation of Spent Fuel Storage and Transport

Series of issues are not clear yet for the proposed 800-ton SF reprocessing facility, such as location, construction schedule and overall cost, etc.

Uncertain issues of 800-ton SF reprocessing facility

Since series of issues are not clear yet for the proposed 800-ton SF reprocessing facility, such as location, construction schedule and overall cost, the auxiliary SF storage facility cannot be planned and constructed yet. This poses serious problem for SNF transfer and storage.
1 Situation of Spent Fuel Storage and Transport

China SF disposal fund —regulated by government

"Temporary management measures of China SF disposal fund"

"Project management measures of China SF disposal fund"

Demander
SF transport
SF storage
SF reprocess

Service Provider
Capacity construction and project execution

Consultor
Technical support

Fund payer, SF storage/transport demander

Set rule, manage fund and projects
2. Challenges of SF Storage and Transport

Challenge 1: Reprocess capacity never catch up SF Away-From-Reactor demand

Reprocess capacity never catch up SF AFR demand. SF storage should be an indispensable link of China Nuclear Fuel Cycle.
2. Challenges of SF Storage and Transport

Challenge 2: SF storage capacity can’t meet AFR demand.

SF storage capacity can’t meet AFR demand. Dry storage should be an important supplement.
2. Challenges of SF Storage and Transport

Challenge 3: SF transport capacity is far less than out-transfer demand.

Only road transport and SF transport capacity is far less than out-transfer demand.
2. Challenges of SF Storage and Transport

Challenge 4: Uncertain issues of 800-ton SF reprocessing facility will bring risk for SF transport and storage.

If SF from all reactors of China are transferred to Northwestern part of China, and the reprocessing plant is settled somewhere else. Consequent safety risk and disadvantage of increased overall cost during possible secondary transport, which will be in large scale and intensive.
01. Requirement of SF Storage and Transportation in China

02. Situation and Challenges of SF Storage and Transportation

03. Suggestions
1. Spent Fuel Storage and Transport

**Suggestion 1:** SF Interim Storage should be considered as an indispensable link of China Nuclear Fuel Cycle.

**Suggestion 2:** Besides reprocessing facility and matching pool, SF railway, seafaring, multi-mode transport system and SF regional storage facility should be demonstrated and constructed as soon as possible. Urgent demand for SF storage and transport (e.g. Daya Bay NPP) should be taken into account as a whole in advance.

**Suggestion 3:** Nuclear power demand, other than reprocessing demand, should be the major consideration of SF storage and transport capacity buildup. Capacity adapted to our nuclear power scale should be built.
Suggestion 4: More relevant parties should be taken into reprocessing facility affairs under the leading of government. It also should strengthen evaluation, surveillance and top-level design of SF reprocessing for further development of China Nuclear Fuel Cycle.
China General Nuclear Power Corporation would like to join with all relevant parties to work on back-end of nuclear fuel cycle of China, and to contribute to the sustained development of China nuclear power!