Experiences on Pre-Construction & Construction of Karachi Nuclear Power Plant Unit-2 & 3

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Member Power, Pakistan Atomic Energy Commission
### Nuclear Power Plants of Pakistan

<table>
<thead>
<tr>
<th>Plant</th>
<th>K-1*</th>
<th>C-1</th>
<th>C-2</th>
<th>C-3</th>
<th>C-4</th>
<th>K-2</th>
<th>K-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (MWe)</td>
<td>137</td>
<td>325</td>
<td>330</td>
<td>340</td>
<td>340</td>
<td>1100</td>
<td>1100</td>
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</tbody>
</table>

* KANUPP was permanently shutdown for decommissioning on August 01, 2021 after 50 years of safe operation.

**4 NPPs at Chashma**

**K-1, 1st NPP of Pakistan**
Pre-Construction Activities of Karachi Nuclear Power Plant Unit-2 & 3

- Site Registration
- Construction License

**Site Registration**

Application to the regulator, with the following documents:

i) Site Evaluation Report (SER)

ii) No Objection Certificates (NOC) from relevant departments of the federal, provincial and/or local governments

iii) Quality Assurance Program.
Pre-Construction Activities

2008

Hydrology Studies
Metrology Studies
Seismic Studies
Preparation of SER
Review of SER by PNRA

Establishment of K-2 and K-3 Office (November 15, 2005)
Completion of Acquisition of 585 Acre land (August 16, 2008)
Submission of SER to Regulator (PNRA) (November 2011)
Incorporation of review comments
Registration of K-2 Site (February 28, 2013)
Signing of Contract
Availability of Construction Power Supply (March 01, 2014)
Registration of K-3 Site (May, 2014)
Construction Schedule of K-2

- **Ground Breaking (November 26, 2013)**
- **Excavation**
- **Civil Construction**
- **Installation**

**Excavation:**
- **Duration:** 16 Months
- **Start:** Mar 2014
- **End:** Aug 2015

**Civil Construction:**
- **Duration:** 33 Months
- **Start:** Aug 2015
- **End:** May 2016

**Installation:**
- **Duration:** 40 Months
- **Start:** May 2016
- **End:** May 2019

**Duration:**
- **Total:** 40 Months

**Dates:**
- **Nov 26, 2013**
- **Mar 2014**
- **Aug 2015**
- **May 2016**
- **May 2019**
During Construction of K-2, there were two major activities:
1. Permission for Commissioning
2. Fuel Load Permit

Permission for Commissioning
1. Commissioning Program
2. Quality Assurance Program for Commissioning

<table>
<thead>
<tr>
<th>Commissioning Program Preparation</th>
<th>Preparation</th>
<th>Review by Regulator</th>
<th>No. Licensing Questions</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2018– May 2019 (8 Months)</td>
<td></td>
<td>June 2019 – Aug 15 2019 (3 months)</td>
<td>149</td>
<td>Sep 17, 2019</td>
</tr>
</tbody>
</table>
## Activities Performed During Construction

<table>
<thead>
<tr>
<th>Activity</th>
<th>Docs in #</th>
<th>Man-hour (m-h)</th>
<th>Total m-h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning Test Procedure</td>
<td>628</td>
<td>40 m-h/procedure</td>
<td>25128</td>
</tr>
<tr>
<td>Commissioning Program</td>
<td>1</td>
<td>2112 m-h/Month (5 months)</td>
<td>10560</td>
</tr>
<tr>
<td>Commissioning Training Program</td>
<td>1</td>
<td>16 m-h/day (2 months)</td>
<td>704</td>
</tr>
<tr>
<td>Commissioning Personnel Training</td>
<td>Activity</td>
<td>8 m-h/day (35 months)</td>
<td>6160</td>
</tr>
<tr>
<td>System Operating Procedures</td>
<td>276</td>
<td>200 m-h/procedure</td>
<td>55200</td>
</tr>
<tr>
<td>Abnormal Operating Procedures</td>
<td>59</td>
<td>140 m-h/procedure</td>
<td>8200</td>
</tr>
<tr>
<td>Emergency Operating Procedures</td>
<td>49</td>
<td>120 m-h/procedure</td>
<td>5880</td>
</tr>
<tr>
<td>Alarm Response Procedures</td>
<td>164</td>
<td>164 m-h/procedure</td>
<td>22960</td>
</tr>
<tr>
<td>Administrative Procedures</td>
<td>95</td>
<td>120 m-h/procedure</td>
<td>11400</td>
</tr>
<tr>
<td>Operation Training Manual (374 Sys)</td>
<td>100 men</td>
<td>6 m-h/day (1 year)</td>
<td>147000</td>
</tr>
<tr>
<td>Emergency Preparedness &amp; Planning</td>
<td>1</td>
<td>16 m-h/day (6 months)</td>
<td>1920</td>
</tr>
<tr>
<td>Surveillance Programs</td>
<td>164</td>
<td>320 m-h/program</td>
<td>11520</td>
</tr>
</tbody>
</table>
Following documents were submitted to PNRA for fuel load permit:
1. Final Safety Analysis Report (FSAR)
2. Probabilistic Safety Analysis Level One Plus Report (PSA Level 1 plus)
3. Commissioning Reports of Stage A
4. Technical Specifications
5. Radiation Protection Program
7. Inspection Program
8. Fire Protection Program
9. Environmental Monitoring Program duly approved by our Environmental Protection Agency (EPA)
11. Pre-service Inspection (PSI) and In-service Inspection (ISI) Program.
12. Physical Protection Program.
Fuel Load Permit Contd.

14. Demonstration of the implementation of Emergency Preparedness Plans
15. EPP & Physical Protection Program, drills/exercises
16. Stage A tests & review of test reports

Additional documents

- Programs for maintenance, testing, surveillance and inspection of structures, systems and components important to safety
- Fire Protection Program

<table>
<thead>
<tr>
<th>FSAR Preparation Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
</tr>
</tbody>
</table>
**Major Challenges Encountered During Project**

(Challenge 1)

**Development of Manpower for Operation & Maintenance**

**Operation Team Preparation**

- Typically 6~7 years are required for training of O&M manpower.
- A mix of fresh and experienced manpower from Chashma and Karachi plants
- Preliminary training Manpower at CNPGS and KANUPP
- Participation in operation during commissioning
- Advanced training at Full Scale Training Simulator for operations.
- Advanced training at Full Scale Training Simulator for operations. Timely availability of FSTS helped in training of operations manpower
- Maintenance Training of experienced and fresh manpower at Vendors’ facilities and Reference Plant
<table>
<thead>
<tr>
<th>Description</th>
<th>Qualification</th>
<th>#</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers for SS License</td>
<td>Elec., Mec., Chem. Nuclear</td>
<td>15</td>
<td>6 years before initial fuel loading</td>
</tr>
<tr>
<td>Engineers for SE License</td>
<td>Elec., Mech., Chem.</td>
<td>30</td>
<td>4 years before initial fuel loading</td>
</tr>
<tr>
<td>Local Control Rooms</td>
<td>Diploma (Elec., Mec., Chem. Electronics)</td>
<td>100</td>
<td>2-3 years before initial fuel loading</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Description</th>
<th>Qualification</th>
<th>#</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOP Sections</td>
<td>(Elect, Mech, Chem, Electronics)</td>
<td>22</td>
<td>4 Y &lt; IFL</td>
</tr>
<tr>
<td>NI Section</td>
<td>(Elect, Mech)</td>
<td>26</td>
<td>4 Y &lt; IFL</td>
</tr>
<tr>
<td>CI Section</td>
<td>(Elect, Mech)</td>
<td>20</td>
<td>3 Y &lt; IFL</td>
</tr>
<tr>
<td>Elect. Section</td>
<td>Electrical</td>
<td>20</td>
<td>4 Y &lt; IFL</td>
</tr>
<tr>
<td>I&amp;C Section</td>
<td>Electronics</td>
<td>24</td>
<td>3 Y &lt; IFL</td>
</tr>
<tr>
<td>GTS</td>
<td>(Elect, Mech, Chem, Electronics)</td>
<td>15</td>
<td>3 Y &lt; IFL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Experienced)</td>
</tr>
<tr>
<td>TSS</td>
<td>(Elect, Mech, Chem, Electronics)</td>
<td>32</td>
<td>3 Y &lt; IFL</td>
</tr>
</tbody>
</table>
(Challenge 2) 500kV Interim Arrangement for K-3

- New Plant
- Old Coal Fired Plant
- K-2/K-3 Common Switchyard
- Grid Station 1
- Grid Station 2
- Grid Station 3
- Power Plant

线路详情:
- Line 1: NKI
- Line 2: Grid Station 2
- Line 3: Matiari
- Line 4: HUBCO; 21km
- Line 5: Jamshoro
- Line 6: Old Coal Fired Plant

其他信息:
- 500kV K2K3 D/C Interconnection with HUBCO-Jamshoro
- 17kkm
- Under Construction 224km
- 102km
- One and a Half Breaker Scheme
Challenge 3
Heavy & Oversized Equipment and Fuel Transportation

Generator Stator
(Heaviest eq. 520 tons)

Polar Crane (longest)
Length 45.272 m (145.53 feet), width 5.655 m and height 4.681 m

Steam Generator
Equipment Weight 365 tons

Fuel (Shifting from Ship to road Trailer)
Heavy & Oversized Equipment and Fuel Transportation

800 Tons Crane installed at Jetty
Challenge 4
Adoption of Operations Mindset from Commissioning Mindset

- Gradual pulling out of the project team and taking over of the production team
- Enough overlap
- Procedures of turnover available well before fuel loading
- Formation of team for each system & equipment takeover
- Identification and procurement of essential spares, tools and consumables
Challenge 5
Manning of Top Management at the Right Time

- Timely appointment of key positions of **operating organization** is vital to transfer the ownership.
- Operating Organization’s Managers must be in place well before start of commissioning. Individual maintenance and operation engineers can still remain partially attached with the commissioning teams for the specific test associated with their systems.
- Experienced personnel for plant management positions
Challenge 6
Litigations

- Construction of K-2/K-3 challenged in courts
- Public awareness program for acceptance of nuclear power plant.
- Engaged litigant through on site visits as well as expert-to-expert liaison.
- Consensus were built by conducting general public meetings, Public and court hearings.
Challenge 7
Schedule Interfacing among Contractors

- Timely completion of owner’s scope of work which requires planning/scheduling/construction in close coordination with all stakeholders majorly with the main schedule.

- For synchronization with main work schedule, the plans of owner scope of work were kept changing to avoid conflicts like availability of land, utilities, procurement, interface etc.

- As the design interface between those buildings and structures which were designed by main contractor but constructed by owner’s subcontractor was not robust, there were a lot of re-scheduling of work.
COVID 19 Measures
- Restriction on movement of owner & contractor personnel, materials & equipment.
- Measures to reduce the impact and losses to Project due to COVID-19:
  - Established quarantine facilities at site
  - Personnel entering the bio secure bubble had to undergo 15 days quarantine at site and multiple PCR tests to prevent contamination of site.
  - Retention of operations and commissioning teams on site in batches.
  - Plant areas were barricaded into zones: “Green Zone” - for bio-secured bubble and “Red Zone” for personnel residing at off-site residential facilities
  - Incentives were given to employees
  - In case of Positive case at site, quick isolation measures to prevent spread.

Others
- Feedback of Fuqing 5 & 6 NPPs
- Experience feedback of K-2 was used at K-3
- PREOSART conducted from March 02 to March 19, 2020.
Thank You