CNS CONFERENCE
Qinshan Project - June 2003
Dr. Ken Petrunik
CANDU CONSTRUCTION IN CHINA
Ahead of Schedule – Under Budget
Contents

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Qinshan Phase 3 – Project Management; Quality; Construction Methods; Integrated Schedules; World Records
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Q3R
Reference Data

- Qinshan III CANDU NPP
  - 2 x 728 MWe by AECL and TQNPC
  - Zhejiang Province, China
- Contract effective – 1997 Feb 12
- Start construction – 1998 Jun 8
- Scheduled in-service:
  - Unit 1: 2003 Feb 12 – Actual 2002 Dec 31
  - Unit 2: 2003 Nov 12- Predicted 2003 July
Major Participants

- AECL overall project manager, designs & supplies NSP, manages NSP construction
- Third Qinshan Nuclear Power Company (TQNPC) owner, manages BOP construction & executes commissioning
- Chinese Construction Contractors CNI-23, HXCC, CNI-22, ZTPC
- Consortium of Hitachi/Bechtel for BOP design and supply
# Contract Structure

<table>
<thead>
<tr>
<th>Project Management</th>
<th>NSP</th>
<th>BOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>AECL</strong></td>
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<tr>
<td>Engineering Design</td>
<td><strong>NSSS Design AECL</strong></td>
<td><strong>BNSP Design CANATOM NPM</strong> BNSP Subcontract</td>
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<tr>
<td></td>
<td></td>
<td><strong>BOP Consortium</strong> Design &amp; Supply Subcontract</td>
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<tr>
<td>Supply</td>
<td><strong>CANATOM NPM</strong></td>
<td><strong>BOP Consortium</strong> Design &amp; Supply Subcontract</td>
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<tr>
<td></td>
<td>NSP Supply Subcontract</td>
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<tr>
<td></td>
<td><strong>Hitachi</strong></td>
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<td></td>
<td>NSP Supply Subcontract</td>
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<tr>
<td></td>
<td><strong>HANJUNG</strong></td>
<td></td>
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<tr>
<td></td>
<td>NSP Supply Subcontract</td>
<td></td>
</tr>
<tr>
<td>Site Construction Management</td>
<td><strong>CANATOM NPM</strong></td>
<td><strong>TQNPC</strong></td>
</tr>
<tr>
<td></td>
<td>Project Management Subcontract</td>
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</tr>
<tr>
<td>Commissioning</td>
<td><strong>TQNPC under guidance and direction by AECL</strong></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td><strong>NSP Construction Contractors</strong> (under AECL direction)</td>
<td><strong>BOP Construction Contractors</strong> (under TQNPC direction)</td>
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<tr>
<td></td>
<td><strong>Hydro Quebec</strong></td>
<td><strong>BOP Consortium</strong> Design &amp; Supply Subcontract</td>
</tr>
<tr>
<td></td>
<td>NSP Training Subcontract</td>
<td></td>
</tr>
<tr>
<td>Heavy Water and Fuel</td>
<td><strong>AECL</strong></td>
<td></td>
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CHALLENGES

- Many participants-not worked together before on a project
- Unfamiliarity with China
- Shortest schedule of any NPP committed in China
- First CANDU in China
- Regionalized construction not able to benefit from prior PWR experience
- Smallest site in China with water on three sides
- Internal focus on jobs in government companies, not on best for task - structural steel had large schedule impact
• Chinese planning milestone based
• Different country and company cultures – AECL – Chinese – Bechtel - Hitachi
• Young inexperienced Chinese commissioning staff
• Complex execution model; owner manages BOP construction, AECL directs NSP contractors - owner pays
• CONTRACT- LUMP SUM with LDs
• AECL first time use of CADDs, Open Top and all electronic document systems---”on the run”
• Needed to take site construction quality from a paper to effective program.
Meeting the Schedule – Qinshan Phase III

- Good people and teamwork among participants
- Project management leadership and culture with good support from head office and freedom to do job within context of total Contract – focal point accountability
- Good client (TQNPC) and local construction contractors
- State of the Art Project Management Tools
- Early planning, integrated schedules and parallel activities
- Improved construction methods-open top
• Large part of design ready at CED for NSP
• Team in place at CED to produce all project procedures at Rev 0 before work started.
• Design by area not system to match actual construction program
• Effective training and support from Hydro Quebec Gentilly 2 CANDU 6 station
• Excellent commissioning by integrated Chinese and Canadian Teams

NOTE: PROJECT decisions on CADDS, open top, electronic tools made after Contract signing based on dealing with RISKS and CHALLENGES
Quality a Priority

- Promoted NCR culture
- Used NCRs to control and stop work on a localized area
- Used stop work orders to set policy and direction
- Electronic document system supported quality records and processes
- “All” expat site staff were quality surveyors
- Quality was a LINE responsibility
- Client and contractors evolved to accepting International Quality Program-cultural shift
- Independent Chinese QS body on NSP program
State of the Art Project Management Tools

- CADDs – LESS errors and better understanding of overall design and equipment to support easier installation – MANY interferences eliminated
- CANDU Material Management System (CMMS)
  - tracks equipment and materials from RFQ to issue for construction
  - system supports ongoing plant operation & maintenance
  - items bar coded for inventory control and reduced costs
State of the Art Project Management Tools (contd.)

- Asset Information Management (AIM) - all “formal” project records in electronic format
  - on-line and common access to official drawings and documents by all parties
  - reduces errors
  - real time access by all parties
    - dramatically improves quality & efficiency
    - reduces costs
- IntEC – Integrated database for wiring/cabling and Instrument calibration with real time access.
Construction Methods
- Modularization & VHL (Open Top)
  • Shortens installation time
  • Work access from top and bottom
  • Reduces construction labor and interferences between contractors
  • Gives schedule flexibility
  • Done on site for Qinshan after Contract signed
  • Improves quality
  • REDUCES COSTS
  • Compensated for other project delays
Integrated Schedules

- 76 event contract milestone schedule
- 8500 event level 2 schedule shows
  - design deliverables
  - equipment deliveries
  - construction & commissioning activities
- Integrated level 3 schedule by construction contractors
- Parallel activities between civil and installation
  - New for Chinese but shortened schedule
Coffer Dam

NOVEMBER 1998
Major Lifts (tons) - (70 lifts done)

- Steam generator - 220
- Temporary roof - 150
- Pressurizer - 103
- Reactivity deck - 43
- Feeder frames - 40 each,
- Condenser shells - 270 each,
- T/G stator - 280
• Evolution of Reference Plant design by Chinese contractors and AECL for modularization of:
  – dousing steel and piping
  – lower dome formwork
  – spent fuel transfer

• AECL staffing featured hands on field staff to provide training for contractors. Unit 2 durations about 3/4 of Unit 1
July 1999
Condenser Heavy Lift Unit 1
Commissioning TEAM

- TQNPC - 1000 staff
- AECL, Bechtel and Hitachi - 46 expat advisors
- 232 TQNPC staff trained at Gentilly 2 NPP in Canada
- Full scope CANDU 6 simulator on-site
- Control room operators licensed by NNSA
- Integrated team very successful
World Records by Chinese Nuclear Contractors CNI 23 and HXCC

- Slipforming Unit 1: 18 days
- Slipforming Unit 2: 14 days
- FC installation Unit 1: 69 days
- FC installation Unit 2: 64 days
- Steam generator installation: 8 hours
- Pressurizer installation: 8 hours
## New Record for Chinese NPP Construction

<table>
<thead>
<tr>
<th></th>
<th>First Concrete to Criticality (Months)</th>
<th>Criticality (Year)</th>
<th>First Concrete to 100% Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qinshan I</td>
<td>77</td>
<td>1991</td>
<td>87</td>
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<tr>
<td>Qinshan II (U 1)</td>
<td>66</td>
<td>2001</td>
<td>70</td>
</tr>
<tr>
<td>Daya Bay U1</td>
<td>71.5</td>
<td>1993</td>
<td>75.5</td>
</tr>
<tr>
<td>Daya Bay U2</td>
<td>69.5</td>
<td>1994</td>
<td>71.5</td>
</tr>
<tr>
<td>Ling’ao U1</td>
<td>56.5</td>
<td>2002</td>
<td>60.5</td>
</tr>
<tr>
<td>Ling’ao U2</td>
<td>55.5</td>
<td>2002</td>
<td>57.5</td>
</tr>
<tr>
<td>Qinshan III (U 1)</td>
<td>51.5</td>
<td>2002</td>
<td>54</td>
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Qinshan Early Completion

<table>
<thead>
<tr>
<th>Plant</th>
<th>Q3 earlier by months from CED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daya Bay 1</td>
<td>FRAMATOM 17</td>
</tr>
<tr>
<td>Daya Bay 2</td>
<td>FRAMATOM 13</td>
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<tr>
<td>Qinshan II-1</td>
<td>CNNC 16</td>
</tr>
<tr>
<td>Qinshan II-2*</td>
<td>CNNC &gt;20</td>
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<tr>
<td>Ling’ao 1</td>
<td>Guangdong 6</td>
</tr>
<tr>
<td>Ling’ao 2</td>
<td>Guangdong 6</td>
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<tr>
<td>Qinshan III-1</td>
<td>AECL 0</td>
</tr>
<tr>
<td>Qinshan III-2*</td>
<td>AECL 0</td>
</tr>
<tr>
<td>Tianwan 1*</td>
<td>MINATOM 13</td>
</tr>
<tr>
<td>Tianwan 2*</td>
<td>MINATOM 18</td>
</tr>
</tbody>
</table>

*predicted
June 2003

• Owner’s staff: 900
• Contractors direct site labour force: 500 (down from 8000 peak)
• AECL & offshore subcontractors: 60 expatriates on site (peak of 180)
• Unit 2 Criticality April 29, 2003
• On Track to Full Power in summer 2003 – months ahead of schedule
Summary and Conclusions

- AECL CANDU 6 built to shortest construction schedule of any NPP in China even though it was first CANDU.
- Experience and achievements of Chinese contractors and owners commissioning group show that with earlier design and procurement, and some added modularization, construction of the CANDU 6 which is an existing design and proven technology, can be shortened to give a 66 month project schedule from CED. NOTE: Much better possible for NEW design (ACR) which integrates design and construction and commissioning during design phase.
HOW WE DID IT
PROJECT MANAGEMENT AND TEAMWORK
CANDU Q3R

- Replicate Qinshan III
- Same design except pump house
- China as project manager
- Same Chinese contractors
- AECL with Hitachi and Bechtel provide equipment and technical support
- Increased localization
- China does commissioning
CANDU Q3R (CONTD.)

- Cost about ¼ less than Q III (1500$ kw)
- Schedule 66 months vs. 72 months for QIII
- Shortest schedule in China supports faster connection to grid.
The last 20 years: 7% p.a. growth
China’s Electricity Generation

Average growth ~ 7% p.a.
China: Total Generating Capacity

- About 1,050 kW/capita – same as Korea today

Total Installed Capacity of:
- USA
- Canada
## Nuclear Potential in China

### Generating Capacity Additions

<table>
<thead>
<tr>
<th></th>
<th>Short Term 2003-2015</th>
<th>Long Term 2003-2050</th>
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<tbody>
<tr>
<td>Total capacity added, MW/yr</td>
<td>30,000</td>
<td>36,000</td>
</tr>
<tr>
<td>Nuclear market share</td>
<td>6%</td>
<td>16%</td>
</tr>
<tr>
<td>Nuclear capacity added, MW/yr</td>
<td>1,800</td>
<td>6,000</td>
</tr>
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</table>
CANDU Opportunities in China

- CANDU advantage is short schedule, economic, fuel cycle flexibility
- Ongoing good performance of Qinshan supporting new projects
- Good Chinese Canadian partnership