Pakistani Current Nuclear Power Program

- Two Operating Nuclear Power Plants, One under Construction

- KANUPP
  125 MWe (Net) CANDU Type reactor, Near Karachi, commercial operation 12/1972

- CHASNUPP-1
  300 MWe (Net) PWR, Near Chasma in the Punjab, commercial operation 9/2000

- CHASNUPP -2
  300 MWe (Net) PWR, Near Chasma, Under construction, commercial operation expected ~2012
Pakistani Current Nuclear Power Program (Cont.)

• All Pakistani Nuclear Power Plants and all fuel Cycle facilities operated by Pakistan Atomic Energy Commission (PAEC)
• Pakistan nuclear safety issues regulated by Pakistan Nuclear Regulatory Authority (PNRA)
• All Pakistani Nuclear Power Plants under IAEA Safeguards
• Pakistan is member of CANDU Operators Group (COG), and of World Association of Nuclear (Plant) Operators (WANO)
• Pakistan attempt to harmonize export control policies to NSG Guidelines (Meetings 2005)
• Pakistan well complied with Reporting Requirements of UNSC Resolution 1540
Pakistan Nuclear Power Expansion Plans

- Pakistan’s 2005 Mid-Term Development Framework (MTDF) calls for total installed Capacity of 8,800 MWe by 2030. Discussions with China re exporting eight 600 MWe units – 4,800 MWe total. Possible imports of ~1,000 MWe units later
- First two 600 MWe units to be imported planned for KANUPP site
- Should only one 300 MWe unit be imported it might be built at Chasma Site as CHASNUPP-3
- Assume all new units of 600 MWe capacity. Need to import 14 units to meet capacity expansion target
- Assume multiple-unit sites 4 x 600 MWe capacity per site
- Need to open three additional multi-unit nuclear sites (In addition to Chasma -2 units, and KANUPP – 1 old unit, 2 new units)
- Number of new sites decline if larger than 600 MWe units are ordered
- Number of new sites increase if not all sites can accept four units or if smaller than 600 MWe units are ordered
Nuclear Plant Import Options for Pakistan

- Proposed U.S. Nuclear Agreement with India may be used by China as precedent
- China may offer mirror-image deal to Pakistan and submit it to NSG approval after U.S./India Agreement is approved by U.S. Congress and by NSG forum
- Under such Agreement:
  - Pakistan submit all nuclear power plants to IAEA Safeguards (Already done)
  - Pakistan military program outside scope of Agreement
  - Pakistan will align export policies with NSG Guidelines & UNSC Resolution 1540 requirements
  - A. Q. Khan’s investigation might be declared completed(?)
  - Pakistan negotiate participation in FMCT regime
Nuclear Plant Import Options for Pakistan (Cont.)

- Pakistan interested in importing 600 MWe nuclear plants from China, based on Qinshan Phase II station now in commercial operation in Zhejiang Province
- Qinshan Phase II station:
  - Domestic Chinese design with French support
  - 55-60 percents domestic content. NI equipment manufactured in Japan
  - Two units station. Commercial operations dates – 2002, 2005
  - Now replicated in China as Qinshan Phase IV station, located near Qinshan Phase II station in Zhejiang Province site
  - Technology not yet exported. Limited operations experience
- Export of Qinshan Phase II plant from China may require Japanese consent if prior approval required by Japan as condition of supply
- China agreement with Pakistan, if approved by NSG may open doors for other nuclear exporters to Pakistan: Canada, France, Russia, eventually U.S.
Pakistan Nuclear Power Program - Security and Safety Issues – Limiting Factors

• Limiting factors on nuclear capacity growth in Pakistan are:
  - PNRA ability to license new sites, certify new reactor designs, regulate operations of existing plants
  - PAEC ability to train fast enough adequate number of stations technical staffs, industry support infrastructure personnel

• Relying on small number of new reactor designs, constructing multi-unit stations, will bring Pakistan benefits of Plant standardization, on-site replication
Pakistan Nuclear Power Program - Security and Safety Issues – Safety Considerations

• Standardization, on-site replication of new reactor designs, carry risks of generic design defects identified later in life, requiring fleet-wide modifications & loss of generation
• New reactor designs maybe more susceptible to common-mode failures affecting entire stations or several stations
• New, not well trained station staffs may exacerbate initiating events, propagating them to significant nuclear accidents
• Grid-Station interactions may propagate station shutdown to grid instability, ultimately electric grid collapse, with severe economic, social, consequences
• Natural disasters could affect multiple-unit stations, particularly with inexperienced staff, leading to further grid instability
Pakistan Terrorist Infrastructure and Sectarian Violence

- Large number of terrorist organizations allowed to operate in Pakistan, in order to:
  - Encourage, once-removed, unrest in Indian-controlled Jammu & Kashmir
  - Fight, repel, Soviet Russia invasion of Afghanistan
  - Maintain friendly political regime in Afghanistan
- Estimated ~ 40 Terrorist Organizations now active in Pakistan
- Current nuclear installed capacity of 450 MWe or 0.45 GWe
- Define notional ratio of 90 \{\text{Terrorist organizations/GWe of installed nuclear capacity}\}
- Ratio will decline to 52 \{\text{Terrorist Organizations/GWe}\} when CHASNUPP-2 unit is completed
- Assume by 2030 only 20 active terrorist organizations, 8.8 GWe of installed nuclear capacity. Compute a ratio of 2.3 \{\text{Terrorist Organizations/GWe}\}, still a world record
# List of Terrorists and Extremists Groups in Pakistan

<table>
<thead>
<tr>
<th>Terrorist Groups</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Domestic organizations</strong></td>
<td><strong>Trans-National Organizations</strong></td>
</tr>
<tr>
<td>1. Lashkar-e-Omar (LeO)</td>
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| 2. Al-Akhtar Trust |
| 3. Rabita Trust |
| 4. Ummah Tamir-e-Nau |

**Trans-National Organizations**

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Pakistan Terrorist Infrastructure and Sectarian Violence (Cont.)

- Another way to consider this issue is: Current number of terrorist organizations in Pakistan ~40. Two nuclear plant sites exist. Define 20\{Terrorist organizations/Nuclear Site\}
- By 2030 expect ~20 active terrorist organizations, 5 nuclear station sites or 4 \{Terrorist Organizations/Nuclear Site\}
- Additionally there exist in Pakistan:
  - Sectarian violence between Punjabis and Sindhis
  - Sectarian violence, armed insurrection in Balochistan
  - Taliban, Al Qaeda, foreign Jihadis effective control of North and South Waziristan Provinces
  - Sunni/Shia general sectarian violence, particularly in Karachi
  - Large scale drugs production, use and transport
  - Large scale unregistered weapons supplies & related violence
Safety Problems Associated with Pakistan Nuclear Plants Expansion Plans

Protection of Spent Fuel Storage Pools

- Significant spent fuel accumulation expected in four unit stations as possibly planned for Pakistan
- CHASNUPP Unit discharges ~12 MTHM/Year
- 600 MWe Qinshan Phase II unit estimated to discharge ~ 25 MTHM/year
- CANDU Unit discharges 50% more assemblies, higher grade Plutonium
- After 10 years of operation 4 x 600 MWe Qinshan Phase II station will contain ~ 1,000 MTHM of spent fuel in four storage pools
- Plans for disposition of spent fuel in Pakistani nuclear power program not yet known
- Less than well trained operators might misdiagnose significance of evolving diversion event, institute protection measures
- Less than well trained operators might not know how to handle emergency security events
Security Problems Associated with Pakistan Nuclear Plants Expansion Plans

- **Fissile Material Diversion from Nuclear Power Stations**
  - Multi-unit nuclear power stations will include large stocks of spent fuel in storage pools, fresh fuel supplies, various radioactive sources, shielded containers, etc.
  - Large station staff offer possibility of identifying insiders, willing or coerced, to support terrorist attack plans.
  - Rogue intelligence personnel may provide security measures data to prospective attackers.
  - Stations could represent attractive targets to terrorists interested in acquiring WMD/RDD capabilities.
Security Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont.)

- **Terrorist Attack, Seizure, or Take-Over of Nuclear Power Stations**
  - Multi-unit nuclear power stations represent prestige national programs which terrorist organizations might wish to capture to advertise their cause.
  - Taking-over a nuclear power station might be used by terrorist organization as a bargaining chip to obtain specific concession from central government.
  - Terrorists might attempt to take-over a nuclear station in period of political unrest and/or regime change, to seek specific concessions from incoming regime.
  - In most cases, terrorists motivation to attack would be stronger than security force motivation to defend station. With Insiders support well planned attack might succeed.
Security Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont. II)

- Possible Airplane Attack on Nuclear Power Stations
  - Terrorist airplane attacks could be mounted in two forms: kidnapping large passenger jet airplane, crashing it, relying on mass of jet fuel to burn through breached containment. Or, loading small commercial jet plane with explosives and diving into plant structures
  - Airplane terrorist attack, or truck bomb attacks, are un-ambiguously meant to cause significant radioactive release, large number of casualties in radioactive plume’s wake
  - Multiple-unit nuclear power stations offer attractive targets as they represent prestige national projects which terrorists might wish to destroy. Large number of point targets available on site, in case one target is missed
  - In general the more important target on-site is from perspective of radiation release, the smaller cross section it presents for airplane to hit. Containment building, spent fuel pool building, are smallest identifiable structures on site
Security Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont. III)

- **Military Take-Over of Nuclear Station Sites**
  - Military take-over of nuclear plant site could be initiated by regional commander interested in securing concessions from central government, particularly during periods of political instability or regime change.
  - Multiple-units nuclear power station represents attractive target as national prestige project, or as an economic asset which, if it stopped generating could inflict damage on national electricity supply, grid stability.
  - Physical take-over of station might not even be necessary. Cutting off communications lines or just notifying government of intention, possible troops movements, might produce desired concessions.
Pakistan Nuclear Power Program - Security and Safety Issues (Cont. III)

- Foreign take over of Pakistani Nuclear plants in case of regional war could be attempted as:
  - Protective measure to prevent prospective terrorist attack or take-over
  - Economic warfare measure, denying Pakistan generation from station, causing grid instabilities, economic losses

Multiple-unit nuclear power stations could present economic opportunity or risk of social/economic blowback depending on political, security, stability of Pakistan & its region
Safety Problems Associated with Pakistan Nuclear Plants Expansion Plans - Summary

- Straining PNRA Regulatory Resources
- Inadequate Training of Nuclear Operation Staffs
- Protection of Spent Fuel Storage Pools
- Common-Mode Failures & Impacts on Grid Stability
- Impacts of Natural Disasters
Safety Problems Associated with Pakistan Nuclear Plants Expansion Plans

- **Straining PNRA Regulatory Resources**
  - PNRA will have to license at least three new nuclear station sites in ~16 years
  - PNRA will have to become familiar with, license two or more new nuclear plant designs, offered by several international vendors
  - PNRA will have to supervise safe operation of operating nuclear stations, resisting pressures to increase generation at expense of plant safety

- **Inadequate Training of Nuclear Operation Staffs**
  - Assuming manpower levels of 0.5 – 1.0 Persons/MWe, a 8,800 MWe capacity expansion plan will require qualifying & training 4,400 to 8,800 nuclear O&M staff persons over a twenty years period
Safety Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont.)

- Accelerated staff training program might produce less than well qualified operators, miss persons of security concern, allowing terrorist supporters access to plant operations
- Training manpower for PAEC nuclear power program, military program, national nuclear fuel cycle program, nuclear regulators & nuclear services support infrastructure within ~25 years period might strain Pakistani educational resources
- Less than well trained operators might reduce efficiency of plant operations, lengthen outages, reduce capacity factors. Not acceptable when nuclear capacity represents ~20 percents of total electricity generation. Might increase pressures to generate at expense of safe operation
Safety Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont. IV)

- Common-mode failure event shutting down multiple-unit nuclear station might unbalance regional electric transmission grid. Cause other stations shutdowns, load shedding, potentially regional power blackout. Station could impact grid as much as grid could impact station

• Impacts of Natural Disasters

- Natural disasters such as earthquakes, Monsoon flooding etc could directly impact operation of multiple-unit stations if occurring nearby. Indirect effects could ensue even if disaster occurred in remote area as grid instability percolated to nuclear station site. Impact on both station operation, grid stability could be pronounced
Security Problems Associated with Pakistan Nuclear Plants Expansion Plans - Summary

- Fissile Material Diversion from Nuclear Power Stations
- Terrorist Attack, Seizure, or Take-Over of Nuclear Power Stations
- Possible airplane Attack on Nuclear Power Stations
- Military Take-Over of Nuclear Station Sites
- Foreign Military Attacks on Nuclear Station Sites
Security Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont. IV)

- **Foreign Military Attacks on Nuclear Station Sites**
  - Foreign military take-over of nuclear plant sites could be expected under two contingencies: protective take-over during periods of regime change to prevent terrorists attack on site; or economic damage operation in case of war, aimed at denying generation from station to enemy country, disrupting its electricity grid.
  - Under both cases aim is not to damage station. Take-over could be achieved by commando-style attack during early stage of hostilities to prevent damage. Should reactors be damaged radioactive plume might spread to attacking country population, negating value of operation.
Pakistan Nuclear Power Program - Security and Safety Issues - Conclusions

- Pakistan nuclear plants performance lower than world-wide standards by 10-20 annual percentage points, reflecting limited external support due to Pakistan Nonproliferation stance
- Pakistani operators performed valiantly, maintaining their nuclear plants in safe & secure operating conditions despite limited domestic nuclear infrastructure, limited external contacts
Pakistan Nuclear Power Program - Security and Safety Issues – Conclusions (Cont.)

- Nuclear capacity expansion plans depend on resolving Nonproliferation status through Agreement similar to U.S./India deal, & obtaining NSG approval to such Agreement
- China most likely country to offer such Agreement – mirror image of U.S./India deal
- Other vendor countries will likely follow – Canada, France, Russia, eventually U.S.
- Pakistan nuclear expansion plan requires opening at least three additional multi-unit nuclear power station sites within less than twenty years. This in addition to two existing sites
Pakistan Nuclear Power Program - Security and Safety Issues – Conclusions (Cont. IV)

- Pakistan has allowed emergence of large terrorist infrastructure, with partial intelligence organizations support.
- Pakistan suffers from sectarian strife amongst: Punjabis and Sindhis; Balochistan vs. central government; Sunni vs. Shia communities; foreign terrorist organizations such as al Qaeda & related offshoots vs. central government, etc.
- General instability not conducive to nuclear power growth which requires stable environment.
- Multiple-unit nuclear power stations confer significant economic benefits, However in unstable environment such as Pakistan they present security risks possibly outweighing economic benefits.
Multiple-unit nuclear power stations, representing prestige national projects present high-value attractive targets for various terrorist attacks or military take-over attempts.

Terrorist Attacks could be facilitated by identifying & recruiting insider’s support, amongst large on-site staffs. In general, terrorists motivations to attack stronger than security staff motivation to defend.
Pakistan Nuclear Power Program - Security and Safety Issues – Conclusions (Cont. VI)

• Terrorist attacks could be mounted for:
  - Diverting fissile material
  - Securing concessions from government
  - Destroying station facilities through aerial or truck convoy attacks in nihilistic attempt to advertise their cause

• Military take-over of nuclear power station sites could be attempted by regional commanders to obtain concessions from central government

• The threat of take-over rather than actual attack might produce the sought after concessions so as to prevent damage to stations, electric grid, regional or national economy
ON THE NEGATIVE SIDE

• Pakistan is Nuclear Weapons State Outside NPT Regime. Military Program Facilities Not Subject to IAEA Safeguards. Full Scope Safeguards Can Not be Implemented
• Pakistan did not Sign NPT or Additional Protocol (AP) to its Safeguards Agreement with IAEA
• Pakistani Government may have Known of or authorized Some of centrifuges export deals of A.Q. Khan
• Pakistan might have colluded with DPRK in nuclear technology vs. missiles barter deals & in Support of Libya nascent nuclear weapons program
KANUPP – Karachi Nuclear Power Plant

- Supplied by Canada in Late 1960s, Based on Douglas Point Plant, now Decommissioned
- Oldest CANDU Plant of its type still Operational
- Canadian support stopped in 1975, renewed only in early 1990’s
- Plant performance record quite low due to lack of external support
- Pakistanis managed to operate plant on their own. Fuel manufacturing capability achieved in 1980. Several equipment upgrade program despite limited infrastructure in Pakistan
- Life extension program allow continued operation till 2012 (40 years life)
- Low capacity factors, low burnup achieved, imply high Plutonium fissile content in discharged fuel. Diversion of some fuel assemblies to military program despite safeguards can not be ruled out
## Annual Performance Data for KANUPP

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy (GWe.h)</th>
<th>Capacity (MWe)</th>
<th>Energy Availability Factor (%)</th>
<th>Annual</th>
<th>Cumulative</th>
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<tbody>
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<tr>
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<td></td>
<td>27.94</td>
<td>27.94</td>
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<tr>
<td>2004</td>
<td>183.0</td>
<td>125</td>
<td></td>
<td>24.71</td>
<td>27.84</td>
</tr>
</tbody>
</table>
CHASNUPP-1 Chasma Nuclear Power Plant – Unit 1

• Based on China Qinshan Phase I plant. Exported by China National Nuclear Corporation (CNNC)
• First example of South-South export of commercial nuclear power plant
• Performance record much better than KANUP, still lower than Qinshan Phase I
• Chasma site also houses Pakistani nuclear fuel reprocessing plant based on French design, built, operated by PAEC
• Khushab Plutonium Production Reactor (40 MWth) located nearby
## Annual Performance Data for CHASNUPP-1

<table>
<thead>
<tr>
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<th>Energy (GWe.h)</th>
<th>Capacity (MWe)</th>
<th>Energy Availability Factor (%)</th>
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<tbody>
<tr>
<td>2000</td>
<td>529.15</td>
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<tr>
<td>2003</td>
<td>1809.8</td>
<td>300</td>
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</tr>
<tr>
<td>2004</td>
<td>1750.71</td>
<td>300</td>
<td>66.35</td>
</tr>
</tbody>
</table>
CHASNUPP-2 Chasma Nuclear Power Plant – Unit 2

- Copy of Unit 1, also based on Qinshan Phase I with modifications
- Expected total unit cost ~ 860 Million Dollars
- Chinese loans & export credits of 350 Million Dollars
- Nuclear Island (NI) equipment not yet manufactured in China. Pressure vessel in Japan, Primary pumps in Germany
- Supply contract signed 2004 with CNNC, construction start 2005, Commercial operation expected 2011
- China supplied reactor despite becoming NSG member claiming contract discussions predate NSG membership, contract ‘Grandfathered’
Nuclear Plant Import Options for Pakistan

- All nuclear plant exporters members of NSG
- NSG Export Guidelines require NPT signature, Full Scope Safeguards Agreement with IAEA
- Signing and ratifying Additional Protocol may be added as new condition of export
- Sympathetic NSG members such as China may find it difficult to ignore NSG Guidelines and export nuclear plants to Pakistan
Safety Problems Associated with Pakistan Nuclear Plants Expansion Plans (Cont. III)

- Large accumulation of spent fuel presents target of opportunity for terrorist groups. Station staffs, guard force will have to be trained in security procedures to thwart possible attacks

- **Common-Mode Failures & Impacts on Grid Stability**
  - Common-mode failures could occur in multiple-unit stations based on Qinshan Phase I reactors – old design, or Qinshan Phase II reactors – new complex design
  - Impact of Common-mode failure stronger if station staff is inexperienced
  - If common-mode failure affects several stations with similar reactors – impacts on total electricity generation could be severe