

Nuclear New Build: Requirements Beyond the Technology



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Topics

- Global Context
- Key New Build Requirements
- Examples from AECL experience
- Team CANDU
- Summary



Global Context

- **Worldwide demand for clean-air electrical energy is increasing:**
 - Asia, Europe, Africa, North America
 - 250 GW of new nuclear by 2030
- **Nuclear will play an increasingly important role in delivering secure baseload:**
 - Refurbishment of existing fleets underway
 - New builds being planned
- **Growing move to diversified supply**

“Nuclear energy is the only large-scale, cost-effective energy source that can reduce CO₂ emissions while continuing to satisfy a growing demand for power.”

“Going Nuclear: A Green Makes the Case”, Patrick Moore, The Washington Post, April 16, 2006



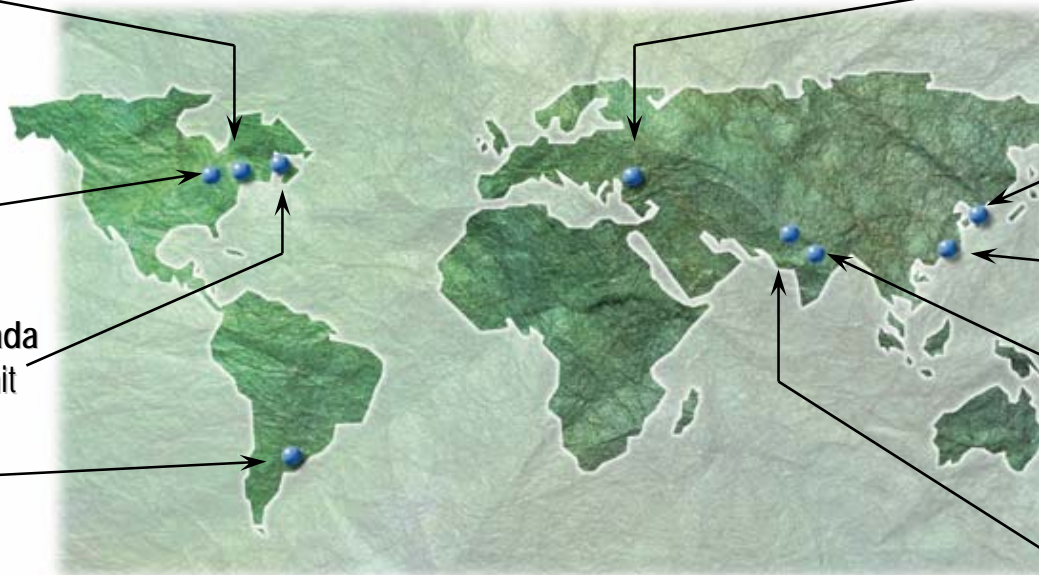
CANDU – An International Success

Quebec, Canada
Gentilly 2 1 unit

Ontario, Canada
Darlington 4 units
Pickering 8 units
Bruce 8 units

N.Brunswick, Canada
Point Lepreau 1 unit

Argentina
Embalse 1 unit



Romania - Cernavoda
2 units

S.Korea – Wolsong
4 units

China - Qinshan
2 units

India
2 CANDU units
15 PHWR units,
3 units under construction

Pakistan
KANUPP 1 unit



Wolsong, S. Korea



Pickering, Canada



Qinshan III, China



Key New Build Requirements

Requirements for nuclear build projects are changing dramatically and go beyond the technology alone:

- Proven product/economic competitiveness
- Innovative business model
- Successful project model with on-time, on-budget delivery
- Operational performance and maintainability
- Ongoing plant and technology support
- Other factors including; robust transmission grids, supportive government policy, availability of existing sites that can be expanded, well defined regulatory processes

AECL is well-positioned to meet ALL these requirements and ensure successful New Builds



A Proven Product...CANDU

AECL's Development Strategy

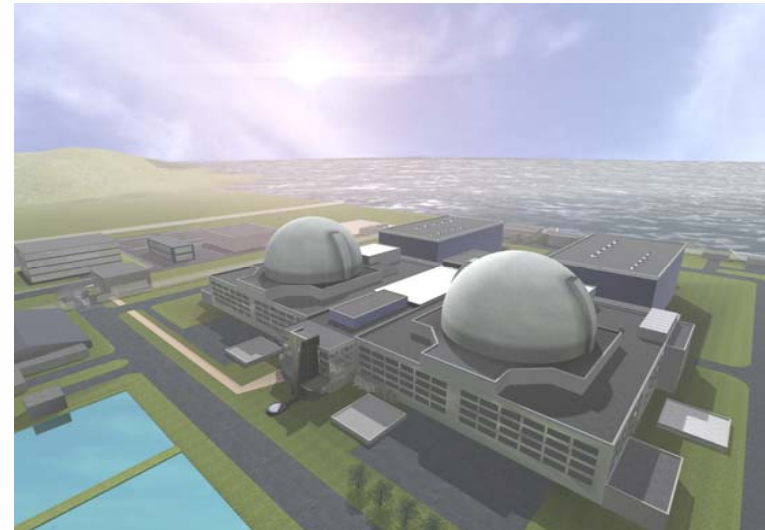
- Innovation based on current experience
- Development program focussed on one reactor technology

Benefits to Customers

- Reduced risk, development costs and development cycle times
- Assurance that CANDU technology is supported in the long term

CANDU Technology benefits from:

- AECL's continuous improvement approach
- Designs that incorporate licensing and operator feedback





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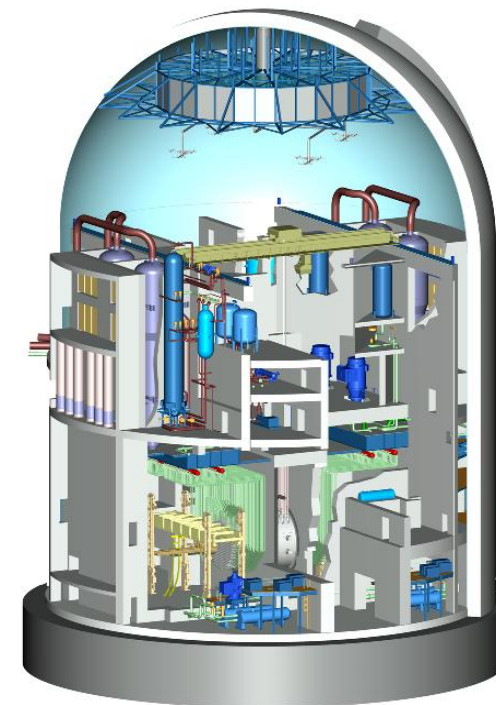
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- Designs that incorporate licensing and operator feedback



ACR-1000 Design

- 1200 MWe class
- Generation III+ technology
- Combines experience of CANDU 6 with new CANDU concepts
- 80% of plant features based on CANDU 6 reference design
- Enhanced safety, economics, operability
- Chosen for generic design assessment in the UK; active new-build initiatives in Canada: Ontario, New Brunswick, Alberta



ACR-1000 Reactor Building
Cutaway



Keeping the CANDU Tradition...

ACR-1000 evolved from the successful CANDU 6

- modular horizontal fuel channels
- simple, economical fuel bundle design
- Separate, low temperature and pressure heavy water moderator
- Safety features: two independent passively-driven safety shutdown systems; water-filled reactor vault
- on-power fuelling
- Reactor building access for on-power maintenance



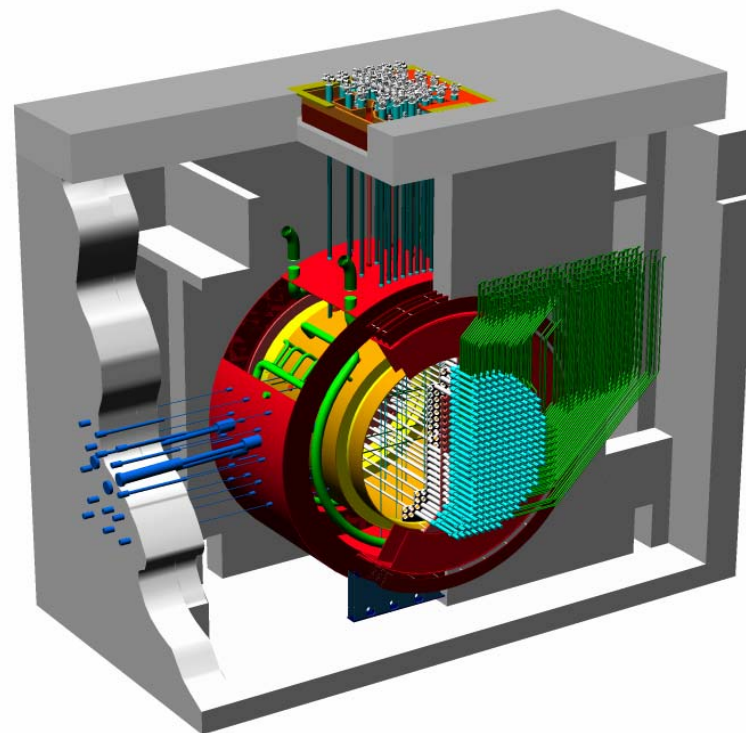
The most recent CANDU 6 plant completed in 2002 and 2003.

- Twin-unit, 728 MW each, in Qinshan Phase III, China
- Built ahead of time and under budget



.... While Embracing Innovation

- Compact core design with improved stability and output
- Steel-lined, 1.8 m thick containment building
- Low-enriched fuel
- Light water coolant
- Thicker pressure tubes; thicker and larger calandria tubes
- Stainless steel feeders and headers
- Further-enhanced passive safety features
- Improved thermal efficiency

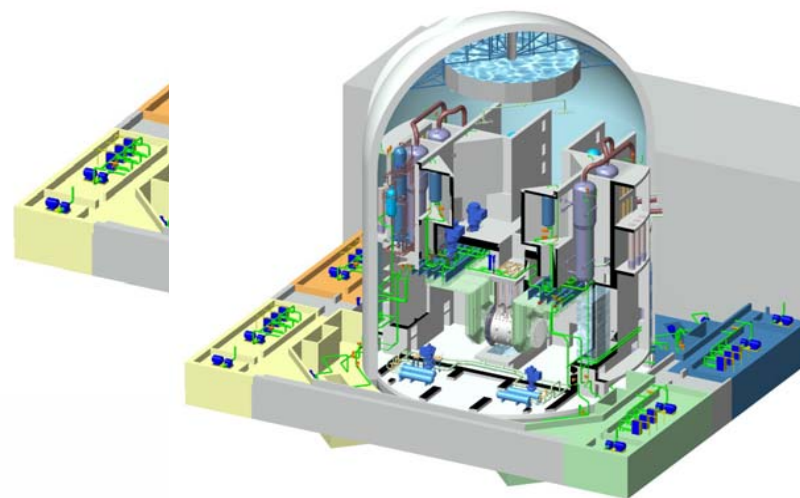
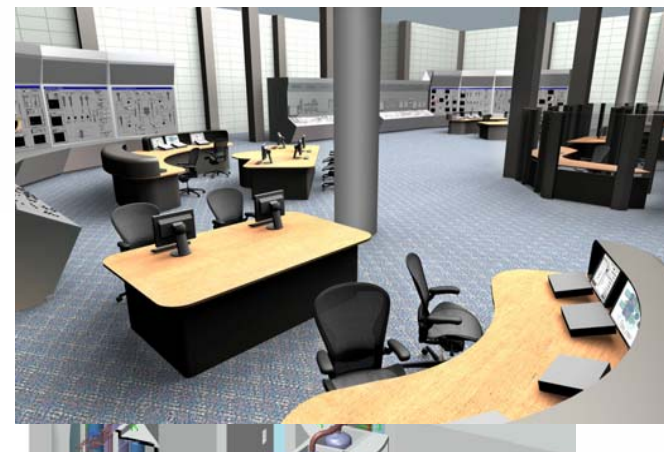


Further improved safety, performance and cost



Further ACR-1000 Innovation

- Mechanical zone control rods; solid-rod guaranteed shutdown state
- Enhanced accident resistance and core damage prevention features
- Further enhanced passive safety
- Option to burn other fuel types: MOX, Thorium, actinides
- Customer-driven, designed-in, improvements in operability and maintainability
- Modern control centre and improved plant performance via SMART CANDU diagnostics
- Four-quadrant design; operational and safety systems separated into four divisions





Innovative Business Model

- Historically, owner assumed most, if not all, of the risk; this is changing
- In major projects, AECL and its partners have taken turnkey responsibility:
 - Full scope—project management
 - Design
 - NSP engineering
 - BOP engineering
 - Equipment, construction, site project management, site commissioning management
 - Commitment to fixed in-service date
- Typical owner's scope:
 - Financing
 - Site, admin. And other ancillary structures
 - Training commissioning and ops staff
 - Licensing and permits
 - Safeguards
- Other models available, depending on customer requirements



Team CANDU

- Formed 2006
 - AECL
 - SNC-Lavalin
 - GE-Hitachi Nuclear Energy Canada
 - B&W Canada
- Further-improved Project delivery
- Proven
 - Project performance
 - Operating performance
 - Product support





Successful Project Model

Primary factors:

- Ongoing engagement (>10 years) in new-build projects
- Supply chain: proven base of international suppliers, to ensure competitive pricing and delivery
- Long-term commitment to developing/improving project management tools
- Proven project management systems
- Modern software: CADDs, project management, materials and wiring management systems
- Modularization, open-top parallel construction
- Cooperative management style



Qinshan Construction



Proven New-Build Project Experience

In-Service	Plant	Status
1997	Wolsong Unit 2, S. Korea	On budget, on schedule
1998	Wolsong Unit 3, S. Korea	On budget, on schedule
1999	Wolsong Unit 4, S. Korea	On budget, on schedule
2002	Qinshan Phase III, Unit 1, China	Below budget, 43 days ahead of schedule
2003	Qinshan Phase III, Unit 2, China	Below budget, 119 days ahead of schedule



CANDU in China

- Qinshan Phase III Project; two CANDU 6 units, completed 2003
- “Paperless” project, demonstrated modular, open-top construction
- AECL and major subcontractors delivered complete financing package through home-country export credit agencies
- AECL, turnkey contractor
 - Construction: Chinese construction contractors
 - BOP design/supply: Hitachi-Bechtel
- Unit 1: under budget, 43 days ahead of schedule, 54 months after first concrete
- Unit 2: under budget, 119 days ahead of schedule





CANDU in Korea

- Wolsong, CANDU 6 units 2, 3 and 4
- Completed in 1997, 1998 and 1999
- AECL prime contractor to KEPCO for NSSS
- KAERI performed engineering, design, supply of NSSS
- AECL architect-engineer for BOP (+ CANATOM and KOPEC) performed BOP engineering and design
- Local manufacturing 70% for units 3 and 4
- Project completed on budget and on schedule





AECL's Construction Strategy

- Construction Strategy:
 - Prefabrication
 - Modularization (ACR-1000 has >120 modules)
 - Very Heavy Lift Crane (VHL)
 - Open Top construction
 - Parallel Construction
 - Advanced engineering tools
- Design optimization and “evolution”
 - New stations built on experience of earlier designs and utility feedback
 - Ongoing material and system improvements for longer life and easier maintenance

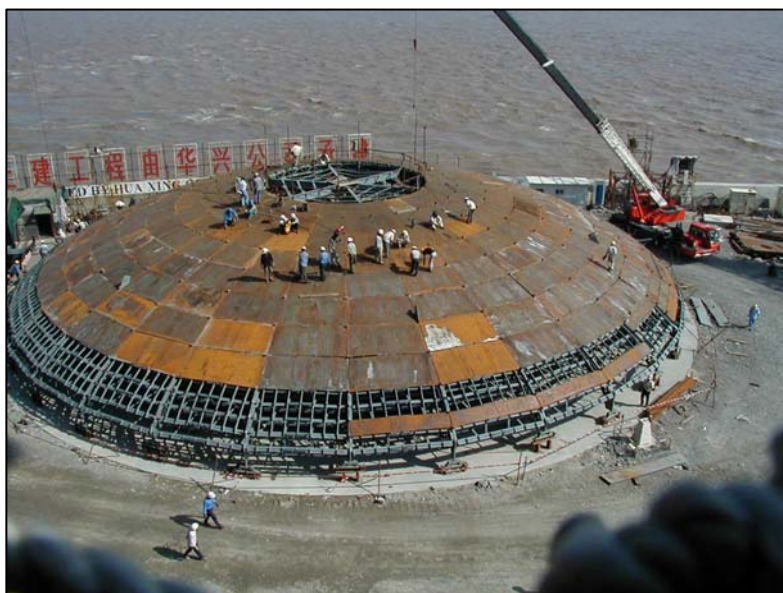




ACR-1000 Module Types

Four major module types considered:

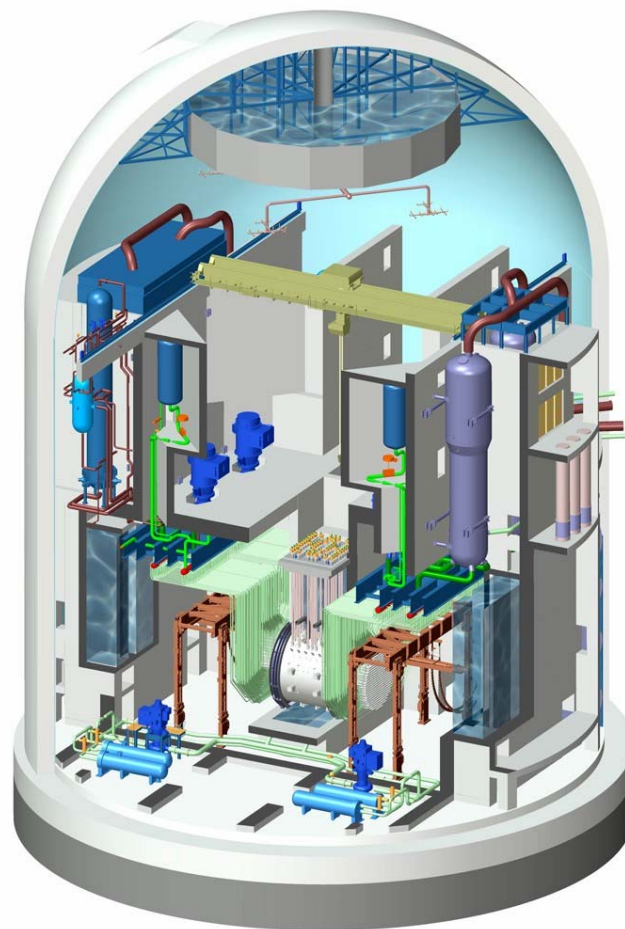
- Large Civil Structure Modules
- Structural Steel shipped to site
- Fabricated adjacent to Reactor Building
- Installation using VHL Crane





Improved Operations/Maintenance

- ACR-1000: >90% lifetime capacity factor; >95% year-to-year, over 60 years
- Performance based on proven CANDU 6 track record: 88.1% lifetime, 92.4% in 2006, plus improved performance of newer OPG/Bruce multi-unit stations (>90%)
- One planned outage every three years, 21 days duration
- Planned mid-life outage for retubing

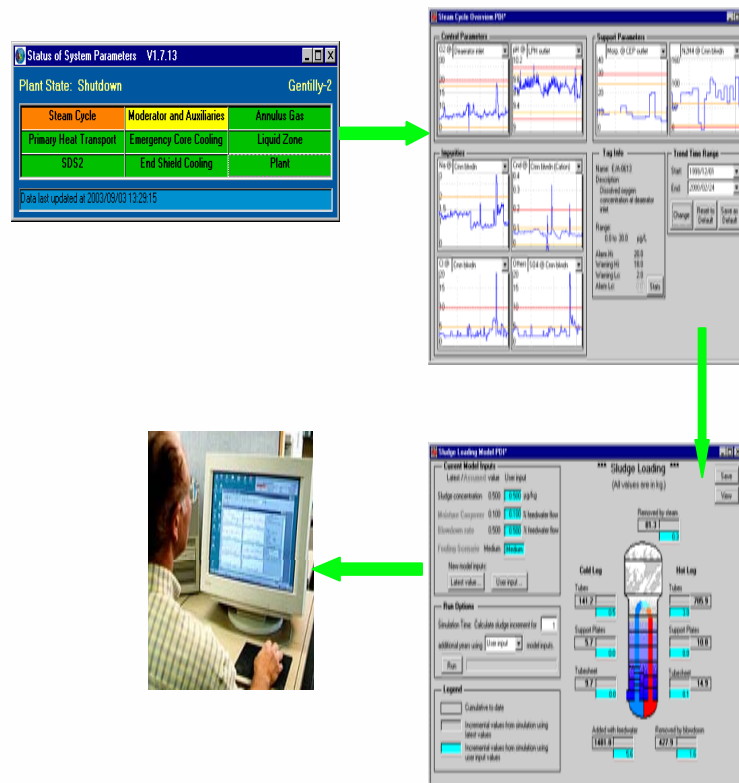




Improved Operations/Maintenance...II

- Improved, long-life materials and experience-based plant chemistry specs
- On-power maintenance strategy
- Improved plant layout: permanent elevator, walkways, platforms; provision for electrical, water, air to facilitate maintenance
- Computerized testing of major safety systems/automatic calibration of in-core detectors
- Increased shielding in radiologically-controlled areas: reduced worker exposure

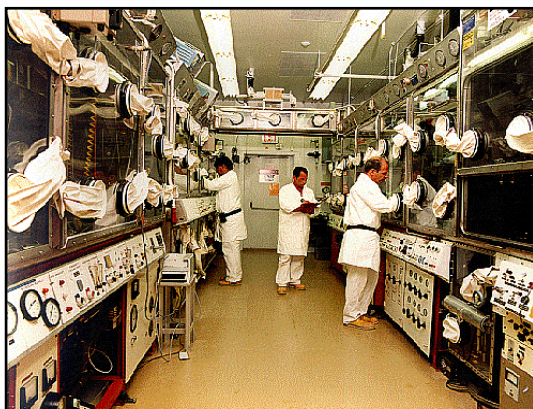
SMART CANDU





Ongoing Technology Support

- The proven success of the CANDU reactor design is underpinned by on ongoing technology support and R&D programs undertaken by AECL and the CANDU Owners Group
- The facilities at AECL's Chalk River Laboratories remain instrumental to the success of the Generation III+ ACR-1000 and the continuing support for operating CANDU reactors worldwide





Summary

- Nuclear power will play even greater role in providing a safe, clean, reliable—and profitable—source of electricity
- Requirements for successful nuclear new build projects extend beyond the technology itself
- In addition to selecting a proven, economically competitive product, the customer must consider:
 - Business model that minimizes financial risk and maximizes ROI
 - Project model that mitigates project/schedule risk
 - Vendor with recent experience: successfully delivering new-build projects on budget, on schedule
 - Operational performance, including commissioning, initial startup, ongoing operability and maintainability
 - Long term commitment to ongoing technical and maintenance support
- **AECL/ACR-1000 will meet utilities' new-build needs and expectations**



 **AECL**

The logo features a large, stylized blue 'A' with a horizontal line through it, and a small circle with a dot on the right side. To the right of the 'A' is the text 'AECL' in a bold, blue, serif font.