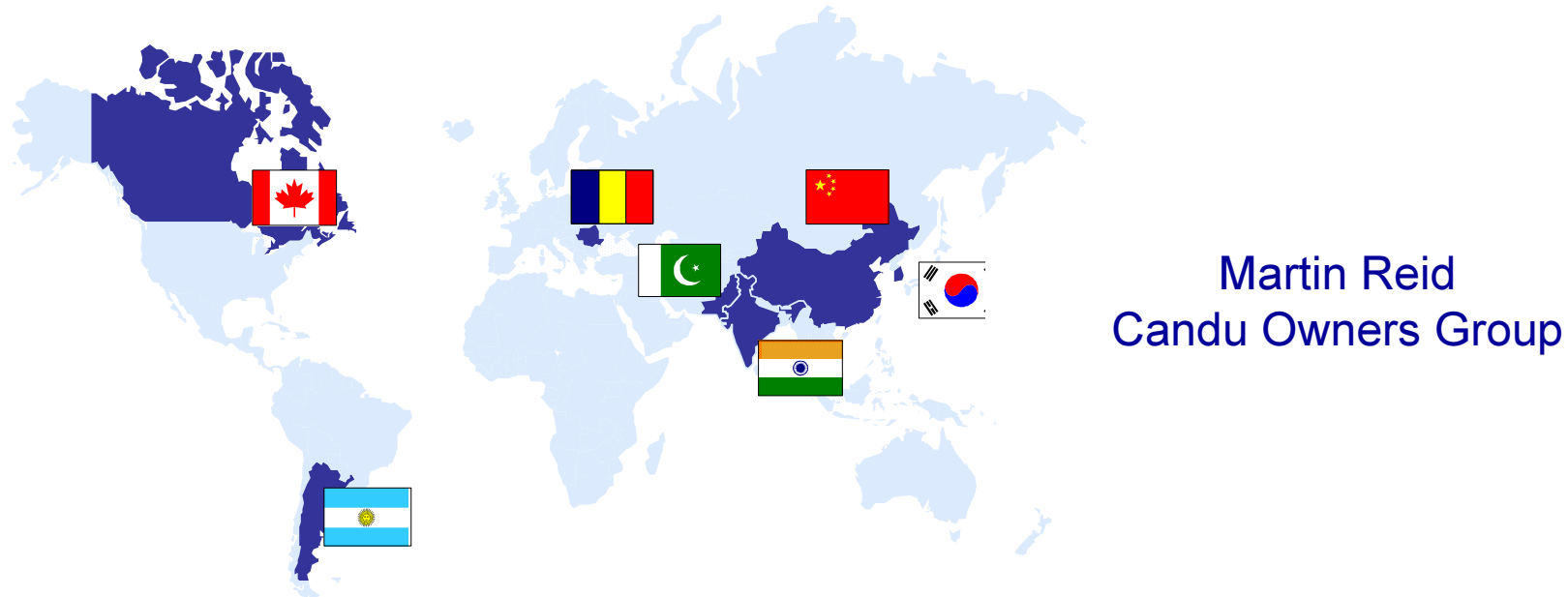
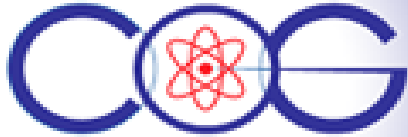




# Ageing Management of Candu Reactors



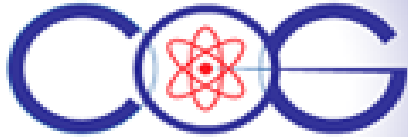
Martin Reid  
Candu Owners Group



# Pickering Experiences

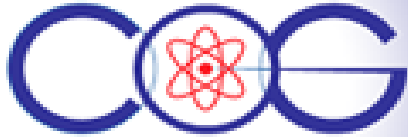
In 1970's - early 1980's Pickering reactors were high performers

- 1983 Pressure Tube failure
  - Hydride embrittlement of Zr pressure tubes
  - Design/construction factors
- Pickering units 1,2 retubed mid-1980s
- Pickering units 3,4 retubed early 1990s
  
- Research and Development programs in Pressure Tubes, Steam Generator tubes established
- Plant control of chemistry conditions in systems was not very rigorous
- Outages in 1980s/1990s due to steam generator tube pitting
  - Led to significant SG inspection programs
  - Chemical cleaning of Pickering SGs
  
- Outages in 2000s due to FAC of carbon-steel feeder tubes



# Refurbishment Status

- Pickering Units 1,4:
  - ◆ Partial Refurbishment completed in 2001-2005 (technically a restart)
  - ◆ Pickering units 2,3 decision not to restart due to economics
- Pickering B, 4-unit Refurbishment decision pending analysis
- Bruce Power units 1,2 Refurbishment in progress, planning for units 3,4
- Candu-6, single units have Refurbishment in progress or being planned:
  - ◆ Pt Lepreau (New Brunswick)
  - ◆ Wolsong 1 (Korea)
  - ◆ Gentilly 2 (Quebec)



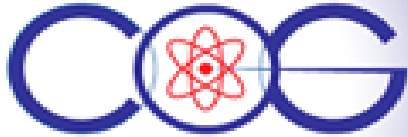
# Drivers for Life Extension

## ➤ Business Drivers

- ◆ Technical Issues
- ◆ Economic Issues

## ➤ Regulatory Drivers

- ◆ Modern Codes/Standards
- ◆ Backfit Policies



# Business Drivers

The viability for Life Extension is primarily business-driven, not regulator-driven. A good technical basis and licensing framework are not sufficient conditions for success.

## ➤ Technical Issues

- ◆ There are no limiting component issues which cannot be resolved technically
- ◆ Current Pressure Tube life is 25yrs
- ◆ A number of units are replacing steam generators during refurbishment
- ◆ Improved materials for feeder replacements to reduce FAC

## ➤ Economic Issues

- ◆ Need to determine the business risks involved in Long Term Operation
- ◆ Usually a capacity factor assessment is key to financial analysis
- ◆ Have Life Cycle Plans/Condition Assessments been completed and costed?
- ◆ How are business risks evaluated?
- ◆ Need an honest assessment of the unknowns
  - Physical condition of inaccessible Structures, Systems, Components?
  - What needs to be inspected/repaired for additional 25/50 years?
  - What is the risk of deferring action?

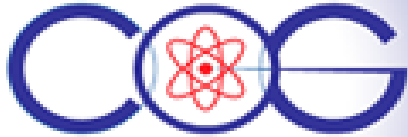


# Regulatory Drivers

At Pickering A, substantial modifications were required to meet modern codes/standards:

- ◆ Improved EQ of electrical and safety systems
- ◆ Seismic improvements
- ◆ Fire Protection
- ◆ ECI improvements to reduce Core Damage Frequency

- Where appropriate, use was made of Risk-Informed Decision Making in evaluating backfit decisions
- Licensing timeframe may or may not constrain the business decision. For example, electrical cables may easily last for an additional 5-year license period (as applied in Canada). However, the cables may last a further 25 years if the ambient temperature is reduced by 5 degrees. The need for a ventilation system upgrade then becomes a business decision.
- More complicated arguments apply when considering the condition of structures in inaccessible locations (e.g. Pickering A Calandria Vault)



\*In Canada, the CNSC has indicated the following views of utility Ageing Management:

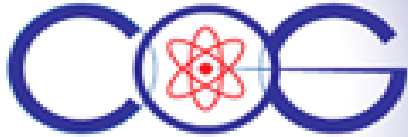
➤ Strengths:

- ◆ Operations and Maintenance programs
- ◆ Inspection/Test programs
- ◆ Major Component specific programs
- ◆ Use of Operating Experience

➤ Weaknesses:

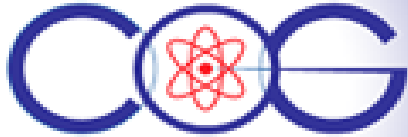
- ◆ Program ownership
- ◆ Data management and documentation
- ◆ Inconsistent approach to integrated AM

\* *Based on the author's review of recent presentations*



# Canadian Utility Views

- A strong R& D program continues, with significant coordination by the Candu Owners Group in areas of:
  - ◆ Fuel Channels
  - ◆ Chemistry and Materials
  - ◆ Safety Analysis methodologies
  
- Life cycle plans are factored into utility business plans
  
- Component Condition Assessments are forming an integral part of refurbishment decision-making process
  
- From a utility perspective, it is important that the Ageing Management programs are integrated within the utility organizational structure, which includes:
  - ◆ System Engineering
  - ◆ Component Engineering
  - ◆ Life Cycle planning



# Conclusions

- Candu plants, both of the multi-unit and single unit (Candu 6) design can operate well and compete in the top quartile of world reactors, and many refurbishments are underway
- Second and even third operating cycles (to ~70 years) are possible from a technical and business perspective
- Nuclear Safety requirements are key drivers, but business drivers will likely be limiting
- Ageing Management programs are necessary to ensure the right short-term decisions are made to keep the long-term options available