Brazil

Current status in NPP I&C and Discussion Topics

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Brazil data

Area: 8,515,767 km²
World’s 5th largest country

Population: 196.7 million
World’s 5th largest population

GDP: 2,477 trillion US$
World’s 6th economy

Per Capita GDP: US$ 12,592
A middle income country

Electrical Generation: 115,0 GW

Nuclear: 2,007 MW (1.74 %)

Sources: World Bank, 2011 (economic data)
Brazilian Government, 2011 (electrical data)
There are currently two NPPs in operation (Angra 1 and Angra 2) ...
... and one under construction (Angra 3) in southeast Brazil.

Future plans

Two NPPs in the northeast and two NPPs in the southeast.
Angra 1 NPP

- Westinghouse PWR type, two loops, 657 MWe
- Commercial operation in 1985
- Instrumentation and Control:
  - Analog I&C predominant
  - Digital, hardwired Reactor Protection System
  - Digital Electric-Hydraulic turbine control
  - Digital Rod Position Indication System
  - Conventional Analog Human-Machine Interface
  - Few automatic control systems
  - SPDS and plant computer using distributed PC-based system
Angra 2 NPP

- Areva (formerly KWU), PWR type, four loops, 1350 MWe
- Commercial operation in 2001
- Instrumentation and Control:
  - Analog and digital hardwired I&C predominant
  - Digital, hardwired Reactor Protection System
  - Conventional Human-Machine Interface
  - Several automatic control systems
  - SPDS and plant computer using distributed PC-based system
Angra 3 NPP (under construction)

- Areva PWR type, four loops, 1350 MWe
- Commercial operation in 2016 (estimative)
- Instrumentation and Control:
  - Digital I&C
  - Software and network based digital system
  - Advanced Human-Machine Interface
  - Fully automatic control systems

Angra 3 I&C configuration is currently being defined with Areva
Fleet Modernization
Angra 1

**Systems to be modernized:**

- Reactor Protection System
- Diesel Generator Sequencer
- Radiation Monitoring System
- Digital Rod Position System
- Control Rod Drive Mechanism
- Steam Dump Control
- Chemical Volume Control System
- Nuclear Instrumentation Systems (ex-core, in-core)
- Alarm Display System
Fleet Modernization
Angra 1

**Systems already modernized or recently installed**

- Plant computer and SPDS
- Turbine control computer
- Turbine vibration monitoring system
- Vent stack computer
- Sub-cooling margin monitor
- Reactor vessel level instrument system
- Recorders
- Digital feedwater control system
- Replacement of Reactor Protection System cards
Fleet Modernization
Angra 1

Systems already modernized or recently installed

Digital feedwater control system

Notes:
2. Operator Station assumed to be mounted in control room or MCB.
   Operator Station monitor and keyboard can be MCB or desk mounted.
3. All controls for feedpump recirculation are soft. Controls for bypass & Main FW valves are soft & hard.
4. Cable lengths are TBD.
5. Controller and I/O are assumed to be mounted in the existing FW cabinets.
6. Each half of each controller and each workstation are dual-attached to the FE network.
7. Fast Ethernet switches can be desk or rack mounted.

Ovation based system supplied by Westinghouse
Fleet Modernization
Angra 1

Systems already modernized or recently installed (cont.)

- Reheaters (pneumatic to digital I&C)
- Containment H₂ monitoring system
- Seismic monitoring system
- Leakage monitoring system
- Loose parts monitoring system
- Chlorination system
- Water demineralization system
Fleet Modernization
Angra 1

Systems already modernized or recently installed (cont.)

Leakage monitoring system
Fleet Modernization
Angra 2

COOPERATION WITH THE EUROPEAN COMMISSION

Eletronuclear developed a two year project with the EC to upgrade Safety Related I&C of Angra 2.

The project aimed to transfer best EU and international know-how on operational safety culture to Angra 2, in order to define a strategy for the replacement of the existing analogue I&C equipment currently used in Angra 2 systems important to safety.

The project reached its conclusion in the beginning of 2013.

Eletronuclear is using the results of this project to modernize Angra 2 safety related I&C.
Fleet Modernization
Angra 2

Systems to be modernized:

- Reactor Protection System
- Reactor Control and Limitation System
- In-core Instrumentation
- Ex-core Instrumentation
- Radiation Monitoring
- Leakage Monitoring System
Fleet Modernization
Angra 2

Systems already modernized or being modernized
- Plant computer and SPDS
- Chlorination system
- Reactor control system
- Water treatment system
Assessing I&C Modernization
Evaluating the obsolescence of the I&C systems

Factors to be considered

- Spare parts availability from the original manufacturer
- Spare parts from alternative suppliers
- Commercial grade replacement (dedication)
- Technical support
- Inventory and shelf life
- Design limitations
- Trends in failure/maintenance
Assessing I&C Modernization
Why modernize I&C?

Obsolescence of installed equipment

*Difficulties in the acquisition of replacement parts.*

Reliability

*Increase in plant events due to failures related to ageing of critical instruments.*

Economic factors

*Increased maintenance costs and reduced plant availability and output*

License renewal for life extension of the plant

*The factors above may constitute obstacles to life extension*
Assessing I&C Modernization

Benefits of modern technology

Modern digital systems
- enhanced human-machine interface
- fault tolerant and redundant control
- improved diagnostics and maintenance tools

Smart transmitters
- reduced maintenance, calibration and drift

Communication networks
- reduced number of cables

Open system architecture
- aiming for supplier independence
Assessing I&C Modernization
Benefits of upgrading to Digital I&C

I&C in the market today is digital
Extremely large operating experience of digital I&C in industry (non-nuclear safety)
Improved performance due to software resources
Increased accuracy and optimization of setpoints
Improved diagnostics
Ensure continued operation for life extension
Assessing I&C Modernization
Problems related to modernization

Human-machine interface and human factors

    including impact on control room configuration and operation

Few nuclear qualified equipment suppliers

Rapidly changing technology

Modification of plant procedures

Plant licensing

    new challenges for safety analysis (software based systems, diversity, CMF)

Training of Operation personnel

Training of I&C maintenance personnel
Discussion Topics

Harmonization for digital I&C licensing

*from safety systems to HMI*

Safety assessment of digital I&C

*including diversity, CMF, Software V&V and best practices*

Other industries

*examination of other industries best practices and technologies (should the incorporation of other industries experiences be a goal?)*

Human factors and digital I&C

*from control room conception in the digital age to awareness and management of the overwhelming information flow allowed by new technologies*
Thank you.