THE NUCLEAR FUEL CYCLE
IN BRAZIL

AQUILINO SENRA
PRESIDENT
INDÚSTRIAS NUCLEARES DO BRASIL (INB)

International Nuclear Atlantic Conference 2013
25/11/2013
GOVERNMENT BRAZILIAN NUCLEAR ORGANIZATION
In Brazil uranium issues are monopoly of the State

President of Republic

Science, Technology and Innovation Ministry

Mines and Energy Ministry

Defense Ministry

National Commission of Nuclear Energy

Eletrobrás (Brazilian Government holding for electricity)

Brazilian Navy

Indústrias Nucleares do Brasil

Eletronuclear (State owned company for nuclear power plants)

CTMSP
INB MISSION

To ensure the supply of nuclear fuel for electric power generation in Brazil.

- Mining
- Conversion
- Enrichment
- $\text{UF}_6$ to $\text{UO}_2$ Conversion
- Pellets
- Fuel Assemblies
Nuclear Fuel Cycle

Fuel Element Fabrication

Conversion of $\text{U}_3\text{O}_8$ into $\text{UF}_6$

Isotopic Enrichment

Conversion from $\text{UF}_6$ into $\text{UO}_2$ powder

$\text{UO}_2$ Fuel Pellet Fabrication

Power Generation

Uranium Mining and $\text{U}_3\text{O}_8$ Concentrate Production
### GEOLOGICAL RESERVES OF URANIUM

#### LOCATION

#### Deposits

<table>
<thead>
<tr>
<th>Deposits</th>
<th>Tons of U₃O₈</th>
<th>Measurements/Indicated</th>
<th>Inferred</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caetité/Lagoa Real</td>
<td>94,000</td>
<td>6,700</td>
<td>100,770</td>
<td></td>
</tr>
<tr>
<td>Santa Quitéria</td>
<td>91,200</td>
<td>51,300</td>
<td>142,500</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>39,500</td>
<td>26,670</td>
<td>66,100</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>224,700</strong></td>
<td><strong>84,670</strong></td>
<td><strong>309,370</strong></td>
<td></td>
</tr>
</tbody>
</table>

**PROGNOSTICATED:**
- **PITINGA (AM):** 150,000
- **RIO CRISTALINO (PA):** 150,000

**ESPECULATIVE:** 500,000

Result from prospecting only 25% of the country
## URANIUM DEMAND x SUPPLY

### RECOVERABLE URANIUM

<table>
<thead>
<tr>
<th></th>
<th>(t de $U_3O_8$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caetité</td>
<td>80,000</td>
</tr>
<tr>
<td>Sta. Quitéria</td>
<td>107,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>187,000</strong></td>
</tr>
</tbody>
</table>

### URANIUM DEMAND

In tons of $U_3O_8$ for the nuclear power plant lifetime (60 years)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Angra 1</td>
<td>4,800</td>
</tr>
<tr>
<td>Angra 2</td>
<td>16,000</td>
</tr>
<tr>
<td>Angra 3</td>
<td>19,200</td>
</tr>
<tr>
<td>N1</td>
<td>15,000</td>
</tr>
<tr>
<td>N2</td>
<td>15,000</td>
</tr>
<tr>
<td>N3</td>
<td>15,000</td>
</tr>
<tr>
<td>N4</td>
<td>15,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Available</th>
<th>Demand</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>187,000</td>
<td>100,000</td>
<td>87,000</td>
</tr>
</tbody>
</table>
INB’s Mining and Industrial Units

UNIT 1

UNIT 2

UNIT 3

Santa Quiteria Project
Phosphate-Uranium Deposit
(State of Ceará)

INB’s Nuclear Fuel Fabrication Plant
State of Rio de Janeiro

INB’s Uranium Concentrate Unit – URA Caetité / State of Bahia
PRODUCTION OF URANIUM CONCENTRATE

CAETITÉ (Bahia)

THE PRESENT
Installed Capacity: 400 t/year

THE FUTURE:
Expanding: 800 t/year in 2017
PRODUCTION OF URANIUM CONCENTRATE
Santa Quiteria Project
Exploitation of the phosphate-uranium deposit

RESERVES

PHOSPHATE: 9 MILLION tons P$_2$O$_5$
URANIUM: 80 THOUSAND tons U$_3$O$_8$

U$_3$O$_8$

Production (2017): 1,100 t
Expanding (2021): 1,500 t

Uranium-bearing phosphate
NUCLEAR FUEL FABRICATION PLANT

ENRICHMENT, UF₆ to UO₂ CONVERSION and Fuel Pellets

COMPONENTS AND ASSEMBLY
Two Units of 1,500 t/year from 2020

Nuclear Fuel Fabrication Plant (FCN)
Conversion Plant Capacity

Premises

✓ **FIRST INDUSTRIAL PLANT:** 1,500 t UF$_6$ /y
  Start Operation in 2020.

✓ **EXPANDING** to 3,000 t UF$_6$ /y
  Starting in 2022.
ISOTOPIC ENRICHMENT PLANT
MODULAR CONSTRUCTION

CAPACITY
✓ 1st step: 100% A3 (2018)
✓ 2nd step: 100% A1 and A3 (2021)
✓ 3rd step: 100% A1, A2 and A3 (2023)
UF$_6$ TO UO$_2$ CONVERSION

Installed Capacity 160 t/year of enriched uranium dioxide:

A1, A2, A3, N1, N2, N3 e N4.
FUEL PELLETS

Installed Capacity 120 t/year of UO$_2$ pellets

A1, A2, A3, N1 e N2.
COMPONENTS AND ASSEMBLY

NUCLEAR FUEL FABRICATION PLANT (FCN)
COMPONENTS AND ASSEMBLY

Installed Capacity in 2 shifts:
240 t/year of enriched uranium
A1, A2, A3, N1, N2, N3 and N4
COMPONENTS AND ASSEMBLY

NUCLEAR FUEL FABRICATION PLANT (FCN)
MATERIALS PRODUCTION PROGRAM
ANGRA 2 FUEL ELEMENT

TOP END
S. STEEL DIN 1.4541 (AISI 321)

FUEL ROD
ZIRCALOY

BOTTOM END
S. STEEL AISI 304L

SPCER GRID
ZIRCALOY

GUIDE THINBLE
ZIRCALOY

SPACER GRIDS
ZIRCALOY

SPACER GRID
INCONEL

NUCLEAR FUEL FABRICATION PLANT (FCN)
Nuclear Fuel Cycle
Production x Demand