The Role of Hydropower in the Brazilian Electrical Energy System Expansion

Workshop “Promoting Flexible Use of Hydropower”

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Principles and Objectives of the Brazilian Energy Policy

- Security of Supply
- Tariff moderateness
- Universal Access
- Respect to Existent Contracts
- Strengthening of the Planning
- Matrix Diversification: Renewable Energy
- National Integration
- National Technological Development
- Compromise with Socioenvironmental Issues
Energy Planning

- Strategic Vision
  - Long Term Studies (up to 30 years)
- Programming Vision
  - Median and Short Term Studies (up to 10 years)
- Monitoring
  - 1 to 3 years visions

Decennial Energy Expansion Plan

Auctions

National Energy Plan

National Energy Matrix

Oil and Gas
Electrical Energy
Transmission
Growth of Domestic Supply of Energy and Gross Domestic Product(%)  

Events 1999-2009 (reduction of the energy intensity):  
- Electricity Supply Crises 2000/2002 (more rationality and efficiency)  
- Global Crises 2008 (strong reduction in the production of energy intensity products)  
- Relatively more exportation of products with less electric energy  
- (more alumina and less aluminum; more iron ore and less steel; etc)  
- Lighter weight and more efficient vehicles  

Events 2009-2019 (increase of the energy intensity):  
- World Cup 2014, Olympic Games 2016, exploration of the pre-salt  
- Strong increase in the production of steel, cellulose, cement and energy sectors  

Sources: IBGE, 2008 and PDE 2019
Final Energy Consumption: International Comparison

Per capita (toe/inhab)

- Brazil: 1.8
- World: 4.4
- China: 4.6
- OCDE: 11.0
- USA: 19.1

Source: IEA Database (2010)
## Macroeconomics Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2009</th>
<th>2019</th>
<th>% per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP ($10^9$ R$)</td>
<td>3.143</td>
<td>4.966</td>
<td>4.7</td>
</tr>
<tr>
<td>Population ($10^6$)</td>
<td>191</td>
<td>207</td>
<td>0.8</td>
</tr>
<tr>
<td>GDP per capita (R$/inhab)</td>
<td>16.416</td>
<td>24.042</td>
<td>3.9</td>
</tr>
<tr>
<td>Domestic Supply of Energy per capita (toe/inhab)</td>
<td>1.274</td>
<td>2.081</td>
<td>5.0</td>
</tr>
<tr>
<td>Domestic Supply of Energy per GDP (toe/$10^3$ R$)</td>
<td>0.078</td>
<td>0.087</td>
<td>1.1</td>
</tr>
<tr>
<td>Final Electricity Consumption per capita (kWh/inhab)</td>
<td>2.231</td>
<td>3.441</td>
<td>4.4</td>
</tr>
</tbody>
</table>

*Source: PDE 2019*
Domestic Supply and Consumption of Energy ($10^6$ tep)

<table>
<thead>
<tr>
<th>Year</th>
<th>DSE (tep)</th>
<th>Consumption (tep)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>62</td>
<td>112</td>
</tr>
<tr>
<td>2009</td>
<td>240</td>
<td>244</td>
</tr>
<tr>
<td>2019</td>
<td>544</td>
<td>430</td>
</tr>
</tbody>
</table>

- Déficit 45% from 1970 to 2009
- Déficit 5% in 2009
- Surplus 23%

Maximum from 1970 to 2009
Energy Domestic Supply Matrix (%)

<table>
<thead>
<tr>
<th>Energy (10^3 toe)</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>World 2008: 12.267 → Brazil 2009: 2.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>World 2020: 14.882 → Brazil 2020: 2.9%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: PDE 2020
Hydroelectric energy is the main energy source in Brazil for electricity.

The Total Potential to be explored is estimated as 260 GW,

only 30% is in operation.
BRAZILIAN WIND POTENTIAL

Height 50m – Turbines of 0,5 MW

143 GW
272.2 TWh/year

Height 100m – Turbines of 2 MW

Expected 300 GW

Source: CRESESB/CEPEL, 2001
Other Options for the Electrical Matrix

- **Nuclear Energy**
  - Sixtieth uranium reserve of the world. (309,000 tons proved and 800,000 ton probable)
  - Nuclear Energy promises a strong expansion after 2030 (55 GW up to 2050).
  - Low emission and secure supply

- **Bioenergy**
  - A large bioenergy program
  - Biomass in the range of 500 MW/year, which means more than 6,000 MW up to 2016

- **Efficiency**
  - A large potential of energy savings: 10%
  - PROCEL
  - PNEf – National Program of Energetic Efficiency
ELECTRICAL MATRIX (%)

2010
544.9 TWh
86.2% renewable

2020
867.3 TWh
87.7% renewable

Source: PDE 2020
Hydropower Inventory Studies

MAIN STUDIES

Approved by ANEEL

1 Tapajós/Jamanxim: 14.245 MW (7 projects)
2 Teles Pires/Apiacás: 3.697 MW (5 projects)

Concluded

3 Araguaia 3.100 GO / MT / PA / TO
4 Jari 1.100 AP / PA
5 Juruena 5.000 AM / MT
6 Branco 2.000 RR
7 Tibagi 1.291,5 PR

Running Studies (PAC)

8 Aripuanã 3.000 AM / MT / RO
9 Sucunduri 650 AM
10 Trombetas 3.000 PA

Total 19.141,5

Source: ANEEL and PAC 2011
## Hydroelectric Expansion

### Operation between 2014 and 2019

<table>
<thead>
<tr>
<th>Project</th>
<th>River</th>
<th>MW</th>
<th>UF</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Belo Monte</td>
<td>Xingu</td>
<td>11,233</td>
<td>PA</td>
<td>2015</td>
</tr>
<tr>
<td>f Teles Pires</td>
<td>Teles Pires</td>
<td>1,820</td>
<td>MT</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>vário</td>
<td>1,716</td>
<td>vário</td>
<td>2014/19</td>
</tr>
</tbody>
</table>

**Subtotal**: 14,769

### Future auctions: Operation between 2015 and 2019

<table>
<thead>
<tr>
<th>Project</th>
<th>River</th>
<th>MW</th>
<th>UF</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 São Luiz do Tapajós</td>
<td>Tapajós</td>
<td>6,133</td>
<td>PA</td>
<td>2016</td>
</tr>
<tr>
<td>b São Roque</td>
<td>Canoas</td>
<td>214</td>
<td>RS</td>
<td>2017</td>
</tr>
<tr>
<td>c Marabá</td>
<td>Tocantins</td>
<td>2,160</td>
<td>PA</td>
<td>2018</td>
</tr>
<tr>
<td>d Itapiranga</td>
<td>Uruguai</td>
<td>725</td>
<td>RS</td>
<td>2018</td>
</tr>
<tr>
<td>e Serra Quebrada</td>
<td>Tocantins</td>
<td>1,328</td>
<td>TO</td>
<td>2018</td>
</tr>
<tr>
<td>3 Torixoréu</td>
<td>Araguaia</td>
<td>408</td>
<td>PA</td>
<td>2019</td>
</tr>
<tr>
<td>1 Jatobá</td>
<td>Tapajós</td>
<td>2,336</td>
<td>PA</td>
<td>2019</td>
</tr>
<tr>
<td>1 Jardim do Ouro</td>
<td>Jamanxim</td>
<td>227</td>
<td>PA</td>
<td>2019</td>
</tr>
<tr>
<td>1 Cachoeira dos Patos</td>
<td>Jamanxim</td>
<td>528</td>
<td>PA</td>
<td>2019</td>
</tr>
<tr>
<td>1 Jamanxim</td>
<td>Jamanxim</td>
<td>881</td>
<td>PA</td>
<td>2019</td>
</tr>
<tr>
<td>1 Cachoeira do Caí</td>
<td>Jamanxim</td>
<td>802</td>
<td>PA</td>
<td>2019</td>
</tr>
<tr>
<td>Others</td>
<td>vário</td>
<td>1,391</td>
<td>vário</td>
<td>2015/19</td>
</tr>
</tbody>
</table>

**Subtotal of future auctions**: 18,615

**Total**: 33,384

*Fonte: PDE 2019, MME (atualizado 01.03.2011)*
## Transmission Lines Expansion

<table>
<thead>
<tr>
<th>Project</th>
<th>State</th>
<th>km</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Interconnection Tapajós – SE</td>
<td>PA, MT, GO and SP</td>
<td>4.400</td>
<td>2017</td>
</tr>
<tr>
<td>2 Interconnection N-NE e N-SE</td>
<td>PA, TO, MA, PI, CE, PE and BA</td>
<td>8.350</td>
<td>2016</td>
</tr>
<tr>
<td>3 Interconnection Teles Pires - SE</td>
<td>MT, GO and SP</td>
<td>4.500</td>
<td>2015</td>
</tr>
<tr>
<td>4 Interconnection Manaus - Boa Vista</td>
<td>AM and RR</td>
<td>750</td>
<td>2014</td>
</tr>
<tr>
<td>5 Reinforcements in SouthEast Region 500 kV</td>
<td>MG, SP, RJ, MT and GO</td>
<td>5.350</td>
<td>2015</td>
</tr>
</tbody>
</table>

(a) Manaus, (b) Belo Monte, (c) AC/RO, (d) Tapajós, (e) Teles Pires, (f) Itaipu, (g) Boa Vista

*Source: PDE 2020*
“Platform” Hydropower Plants

- Implemented in areas with low or no anthropogenic activity
- Reconciliation between electricity generation and environment
- Keep the impact restricted to the plant site
- Recuperation of the affected area during the construction phase
- Operation with small number of staff in turn-over labor periods
### “Platform” Hydropower Plants

<table>
<thead>
<tr>
<th>Hydrograph Basin</th>
<th>HPs</th>
<th>Installed Capacity [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapajós River</td>
<td>7</td>
<td>14,245</td>
</tr>
<tr>
<td>Araguaia River (Mortes River)</td>
<td>2</td>
<td>396</td>
</tr>
<tr>
<td>Madeira River (Ji-Paraná River)</td>
<td>1</td>
<td>350</td>
</tr>
<tr>
<td>Juruena River</td>
<td>3</td>
<td>5,162*</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13</td>
<td>20,153</td>
</tr>
</tbody>
</table>

**Inundation Index:**
- Tapajos Complex – 0.21 km²/MW
- Actual Index – 0.49 km²/MW

*Feasibility

**Source:** Eletrobras (2009), PAC 2

For each km² of intervention, 101 km² preserved
By 2030 the Brazilian Hydropower Potential will be almost completely developed.

Long term studies indicate that the country will need thermal plants (conventional and nuclear) supplying the base load.
OBRIGADO!