Integrated Water and Energy Planning – The Case of Brazil

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This presentation will address the following topics

- Power system in Brazil
- Growing conflicts for the use of water
- Ongoing changes in the institutional framework
- Hydro in jeopardy?
- Light at the end of the tunnel?
Brazil has a large power system, heavily dependent on hydroelectricity

- 110 GW
- 400 TWh
- 85% Hydro
- Estimated potential of 260 GW
- Extensive network, four areas
The perception of Brazil as a water paradise – true, but abundant waters far from consumption centers

- Total river flows – 260 k m³/s
  - 92% in six large basins
  - 80% Amazon basin

- But poorly distributed, on a per capita.year basis
  - Amazon – 500 k m³
  - Driest areas – 1.6 k m³
  - National average – 30 k m³

- Large, populated areas (NE) water (and energy) stressed
  - Semi-arid region
  - Subject to vagaries of rainfall
  - Cyclical droughts
Starting late 90’s, power sector has seen major institutional and regulatory reforms

- Competition in generation and retail, with all concessions granted competitively
- Energy auctions mandatory to captive markets
- Most D assets privatized
- Most new G and T assets built by private sector
- Reliable, improved quality of service and coverage
- Financially sound, cost-recovery tariffs
- Attractive to private capital, the investor by default – domestic and foreign
In the past, power was on the driver’s seat in planning hydro resources

- Relative importance and potential
- Capable institutions
- Existing institutional and regulatory framework
- Until late 1990’s, water planning under Ministry of Energy
- DNAEE in charge of power (and water)
- Plans were designed to maximize power production
- Oftentimes to the detriment of environmental and social concerns
- Multiple uses – an afterthought
Late 1990’s important institutional changes

- Law 9.433/97 created a new paradigm
- National system to manage hydro resources
- Creation of specific regulatory agency (ANA) in 2000
- Water resources to be planned at basin level, and shared among multiple users
- Concessions for the use of water resources
- Mechanisms to mediate conflicts
- Charge for the use of water
- Directionally clear, but slow implementation
Not so peaceful co-existence between water and electricity

- For many years, 900 MW Henry Borden hydro plant has restricted operation – polluted Tiete river cannot be diverted through Sao Paulo to the Billings System lakes
- > 2/3 of Paraiba do Sul river flow being diverted to supply potable water to Rio de Janeiro, chronically affecting reservoirs levels and hydro production
- During 2001 energy rationing, frustrated attempt from the power sector to maximize production of Ilha Solteira, shutting down Pereira Barreto Channel, vital for navigation
- Huge Sobradinho dam in Sao Francisco river being overdrawn to enable irrigation – needs to be recovered
- Tense disputes, seldom planned at the outset, need for administrative mediation, questionable best economic use of water
The situation will likely get worse, before it gets better

- Increase in population and industrial demand for water supply in large cities
- $\frac{3}{4}$ of the concessions granted now are for irrigation
- River flows in some areas under historical averages (e.g. Sao Francisco)
- Mega project (under discussion) to divert $\frac{1}{3}$ of the water from Sao Francisco, to irrigate semi-arid regions
- This river is the major source of power to supply the Northeast, an energy constrained area – no more hydro available
- Growing need for power and to replenish reservoir levels and avoid 2001 crisis
Power system has been operated taking into account multiple uses as binding constraints

- Power system is operated centrally as a tight pool model by a single ISO
- Objective function is to minimize the cost of generation (given transmission constraints)
- Criterion for unit commitment – economic “cost of water” – but just from a power sector perspective
- Multiple uses are taking into account as “constraints” – e.g. flood control, maximum and minimum flows, must run plants, etc.
- Alternative uses are not part of the economic equation – only possible if payment for use of water is implemented, reflecting scarcity
Dispatch rules may accommodate multiple uses

- Central dispatch & optimization in a hydro-thermal system creates volatile cash flows for individual generators
- To address this problem, each generator owns a “share” of total firm and secondary production – which remains relatively stable over time (MRE rule)
- Any energy sub-optimization (for example, due to multiple uses) is therefore socialized
- Not an ideal solution, but it helps reduce uncertainties and accommodate trade-offs between energy and other uses
- But model will collapses if there is a significant reduction in hydro production – e.g. rationing in 2001, or diversion of Sao Francisco River – for all players in generation – will the private sector balk off?
Wake up call – the power sector has realized that it is no longer in the driver’s seat

- Clear manifestation - getting licenses for new hydro plants has become a “nightmare”
  - Long delays – averaging one year, but may be much longer
  - Uncertainty and subjective
  - Constraining hydro generation options for expansion
- Gap has been bridged by expensive, polluting thermal generation – e.g. profile in the first energy auctions

<table>
<thead>
<tr>
<th>Year</th>
<th>Hydro Volume (Average MW)</th>
<th>Hydro Average Price (R$/MWh)</th>
<th>Thermal Volume (Average MW)</th>
<th>Thermal Average Price (R$/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>71</td>
<td>106.95</td>
<td>581</td>
<td>132.26</td>
</tr>
<tr>
<td>2009</td>
<td>46</td>
<td>113.89</td>
<td>855</td>
<td>129.26</td>
</tr>
<tr>
<td>2010</td>
<td>891</td>
<td>114.83</td>
<td>862</td>
<td>121.81</td>
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A recent World Bank study has revealed multiple layers of complexity

- Inventory studies not up-to-date
- Confusing institutional roles between players, states, Federal government agencies
- Cumbersome, lengthy evaluation process by IBAMA - oftentimes biased by extremism
- Excessive power from Public Prosecutor’s Office
- Lack of policy trade-offs between environmental concerns and need for energy
- Difficult to address in the absence of an efficient allocation process, grounded on economics
- Projects examined individually – not strategically
And recommended an integrated approach to enhance power sector planning
Identifying clear opportunities to a more effective planning process

Opportunities for Strategic Planning in the Brazilian Hydropower Sector

<table>
<thead>
<tr>
<th>Level</th>
<th>Definition</th>
<th>Opportunities Available</th>
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<tbody>
<tr>
<td>Policy</td>
<td>A general course of action or a proposal for a general course of action that a government is seeking or may seek and which can guide the decision-making process.</td>
<td>Definition of Energy Matrix National Water Resources Plan National Environment Policy</td>
</tr>
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<td>Plan</td>
<td>A design or strategy with a specific vision, often with coordinated priorities, options and measures for designing and implementing policies.</td>
<td>Strategic Plans for Water Resources and River Basins; National Energy Plan</td>
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<tr>
<td>Program</td>
<td>A coherent and well-organized schedule or timeframe of commitments, proposals, instruments and/or activities for designing and implementing policies.</td>
<td>10-Year Energy Expansion Plan Integrated Environmental Assessment at the river basin level; River Basin Plans.</td>
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The absolute cost of compliance is not a major hurdle – but uncertainty may scare investors in generation.

- **Total Costs (US$ 130/kW)**
  - Property
  - Resettlement
  - Management
  - Social
  - Mitigation

- **Mitigation Costs (US$18/kW)**
  - Flora
  - Fauna
  - Degraded Areas
  - Water Quality
  - Reservoir Cleaning
  - Others
A particular challenge is to develop hydro resources in the Amazon region

- There is a baggage on poor developments in the region
  - Projects implemented without due concern for environmental aspects – e.g. Balbina Hydro (serving the city of Manaus)
  - Old project design only to maximize generation (e.g. Kararao, in the Xingu River)
- Starting in the 80’s enhanced concerns, democratic process and sector capacity (Eletrobras) to deal with environmental and social issues
- There are “good and bad projects” – a change in mindset has enabled the country to find (and improve) good ones
  - 6 GW on Madeira River recently granted, very friendly
  - Project in the Xingu river completely revisited, much more friendly
  - Trade-offs between output and impact mastered by the private sector in the Uruguay river (Ita & Machadinho)
Who should be doing what?

- Someone has to look at multiple uses in an integrated way
- Ideally, one single agency
- However, in the case of Brazil, power sector preempting water uses - DNAEE
- Creation of ANA under another Ministry was the right decision
- Decision making process now involving several Ministries
  - Conflicts take longer to be resolved
  - Perhaps a necessary evil, given history and dynamics
- Different organization approaches may be required in different countries
Perhaps more important – which coordination mechanisms?

Certainly one that looks across multiple uses – “organization follows processes”

With an effective conflict resolution process (e.g., mediation or arbitration) – ANA playing a key role

Ideally, one that takes economic value of water accordingly

Best practice – way that Brazil priced energy during the 2001 energy crisis – based on the value of water, conveyed to all end customers

However, not uniform approach to other competing uses, such as navigation, sanitation, potable water, etc.

Directionally, pricing is the best way to allocate a scarce resource – with proper safety nets in place
Final remarks ...

- Scarcity and multiple uses of water have challenged power sector status as the single owner of those resources.
- New institutional (albeit incomplete and confusing) framework has supported a new multiple use, strategic mindset.
- Power sector has evolved in finding good projects – and make them even better, still at competitive costs.
- This attitude is key to enable further development of hydro resources – the fuel of choice (including in the Amazon region) – co-existing with multiple uses of water.
- Sustainability involves supply and demand side solutions – including rationalization in the end use of water and electricity.
- The 2001 power crisis in Brazil is an international best practices on how conservation and efficient use of scarce resources have a major impact on the security of soppy.