Integrated Water and Energy Planning – The Case of Brazil

Luiz Maurer, The World Bank
Zaragoza, Spain
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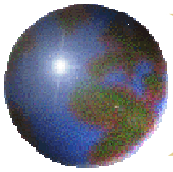
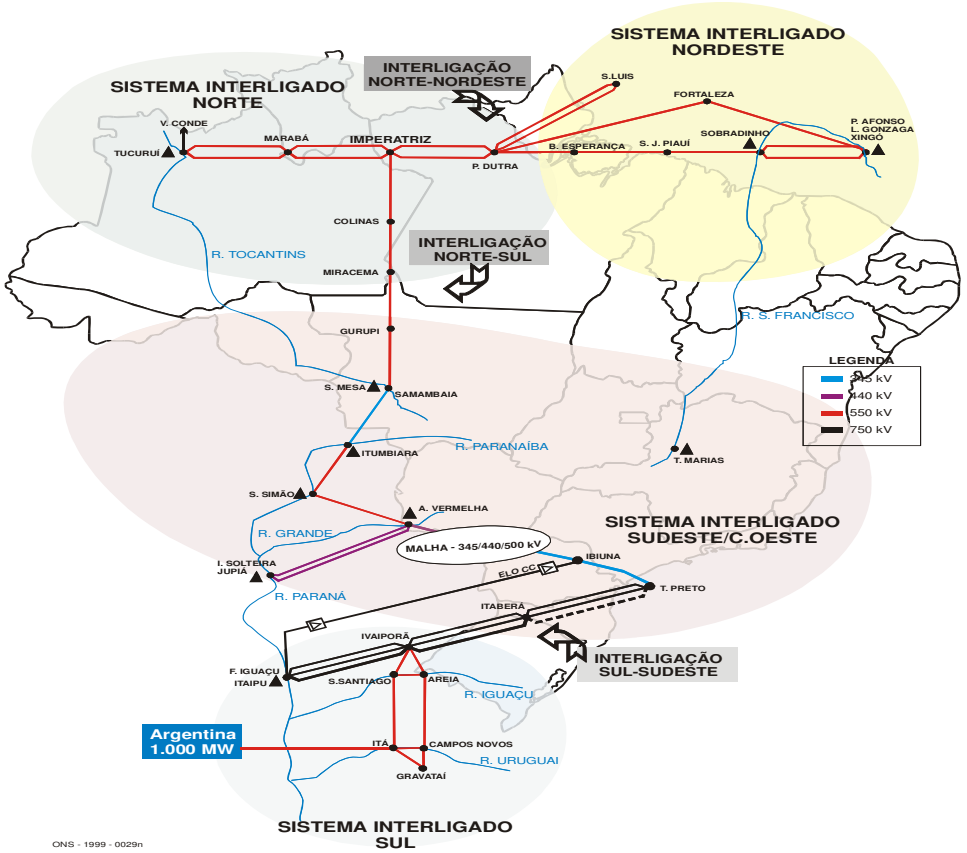


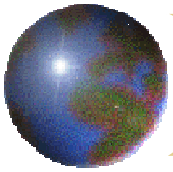
This presentation will address the following topics

- 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

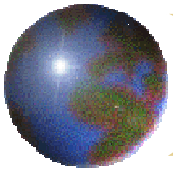
- 110 GW
- 400 TWh
- 85% Hydro
- Estimated potential of 260 GW
- Extensive network, four areas





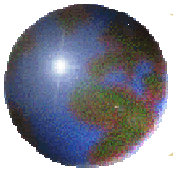
The perception of Brazil as a water paradise – true, but abundant waters far from consumption centers

- Total river flows – 260 k m^3/s
  - 92% in six large basins
  - 80% Amazon basin
- But poorly distributed, on a per capita.year basis
  - Amazon – 500 k m^3
  - Driest areas – 1.6 k m^3
  - National average – 30 k m^3
- 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

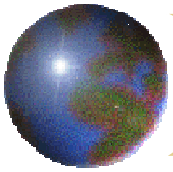
- Law 9.433/97 created a new paradigm
- National system to manage hydro resources
- Creation of specific regulatory agency (ANA) in 2000
- Water resources to be planned at basin level, and shared among multiple users
- Concessions for the use of water resources
- Mechanisms to mediate conflicts
- Charge 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
- ¾ 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 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 –

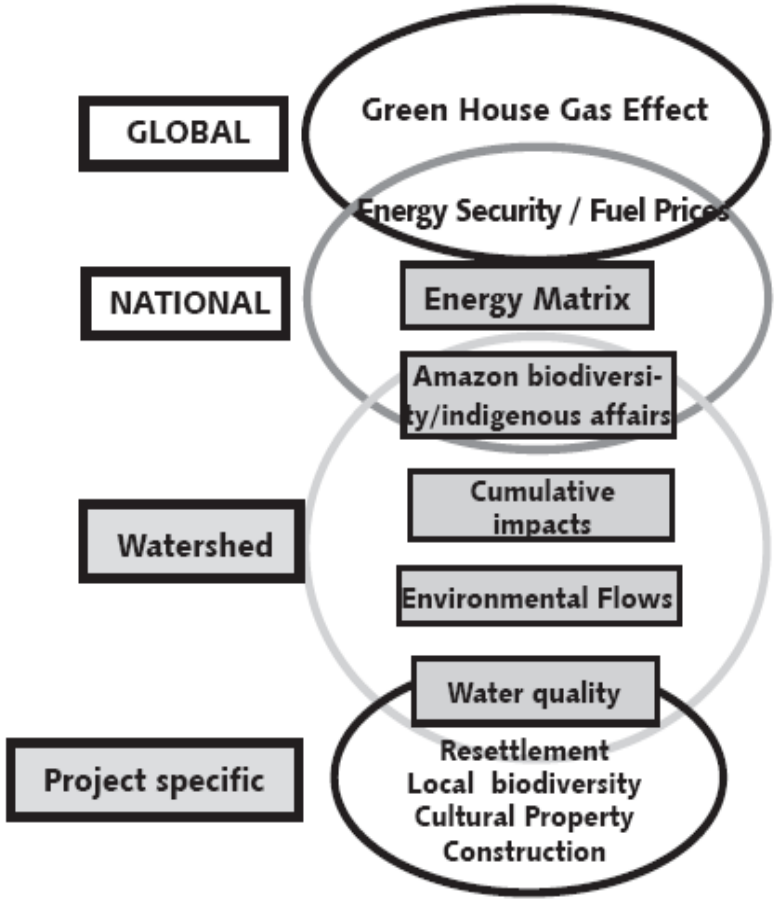
  e.g. profile in the first energy auctions

	Hydro		Thermal	
	Volume (Average MW)	Average Price (R$/MWh)	Volume (Average MW)	Average Price (R$/MWh)
2008	71	106,95	561	132,26
2009	46	113,89	855	129,26
2010	891	114,83	862	121,81

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



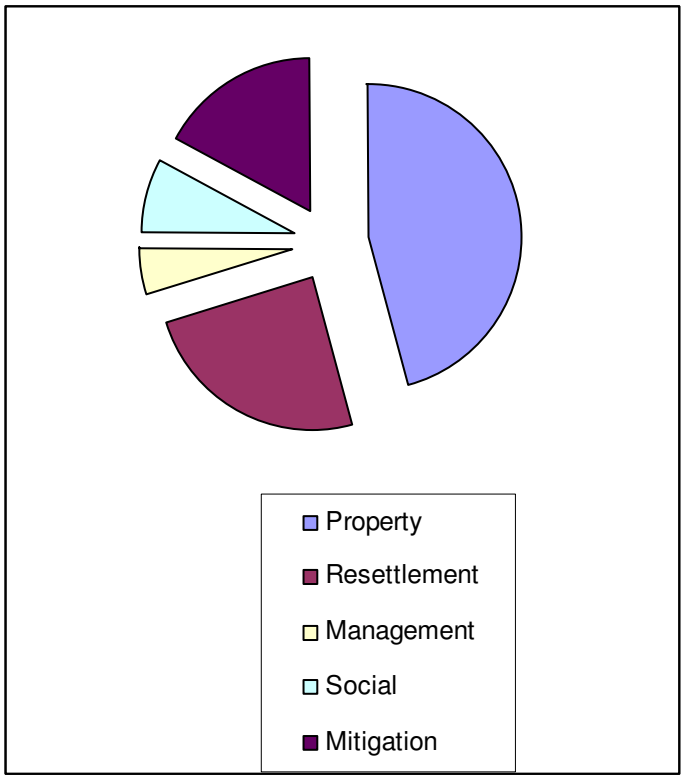
Identifying clear opportunities to a more effective planning process

Opportunities for Strategic Planning in the Brazilian Hydropower Sector

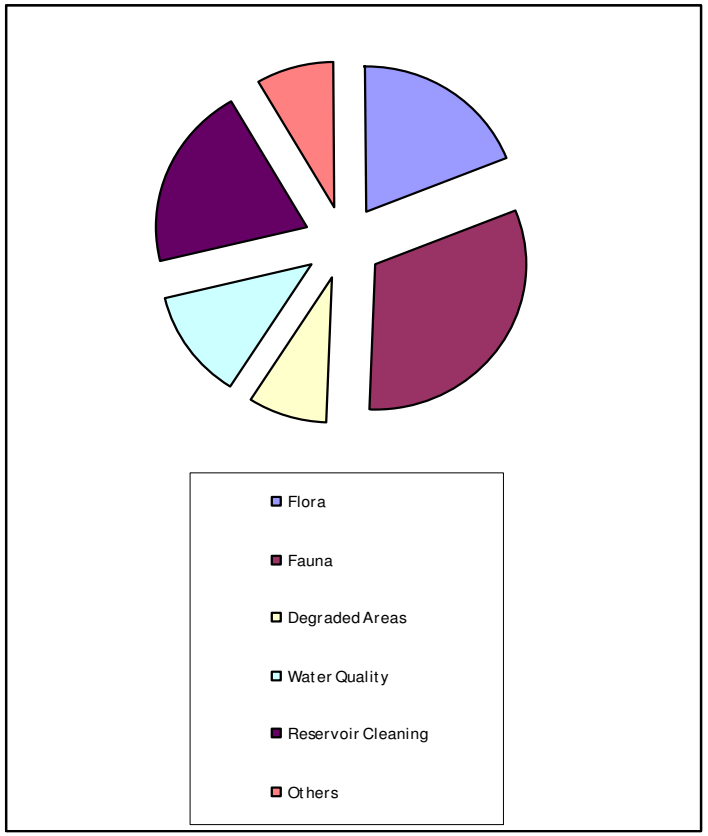
Level	Definition	Oportunities Available
Policy	A general course of action or a proposal for a general course of action that a government is seeking or may seek and which can guide the decision-making process.	Definition of Energy Matrix National Water Resources Plan National Environment Policy
Plan	A design or strategy with a specific vision, often with coordinated priorities, options and measures for designing and implementing policies.	Strategic Plans for Water Resources and River Basins; National Energy Plan
Program	A coherent and well-organized schedule or timeframe of commitments, proposals, instruments and/or activities for designing and implementing policies.	10-Year Energy Expansion Plan Integrated Environmental Assessment at the river basin level; River Basin Plans.

The absolute cost of compliance is not a major hurdle – but uncertainty may scare investors in generation

- Total Costs (US$ 130/kW)



- Mitigation Costs (US$18/kW)



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