

# Water & Energy in Brazil

Jerson Kelman  
Oxford, 10 March 2014



About 10% of the Brazilian population live in the Amazon River basin, where new power plants are being built to tap the energy from the mighty rivers and transmit it to the large urban centers, located thousands of kilometers away.

What is the trade-off between the energy benefits that accrue to the majority of the population and the environmental and socio impacts that affect local people, including indigenous populations?

# Background: The Brazilian Amazon covers 520 million hectares, in nine states





# Brazilian power sector at glance 2012

Installed capacity ~ 121 GW

Hydro installed capacity 70%

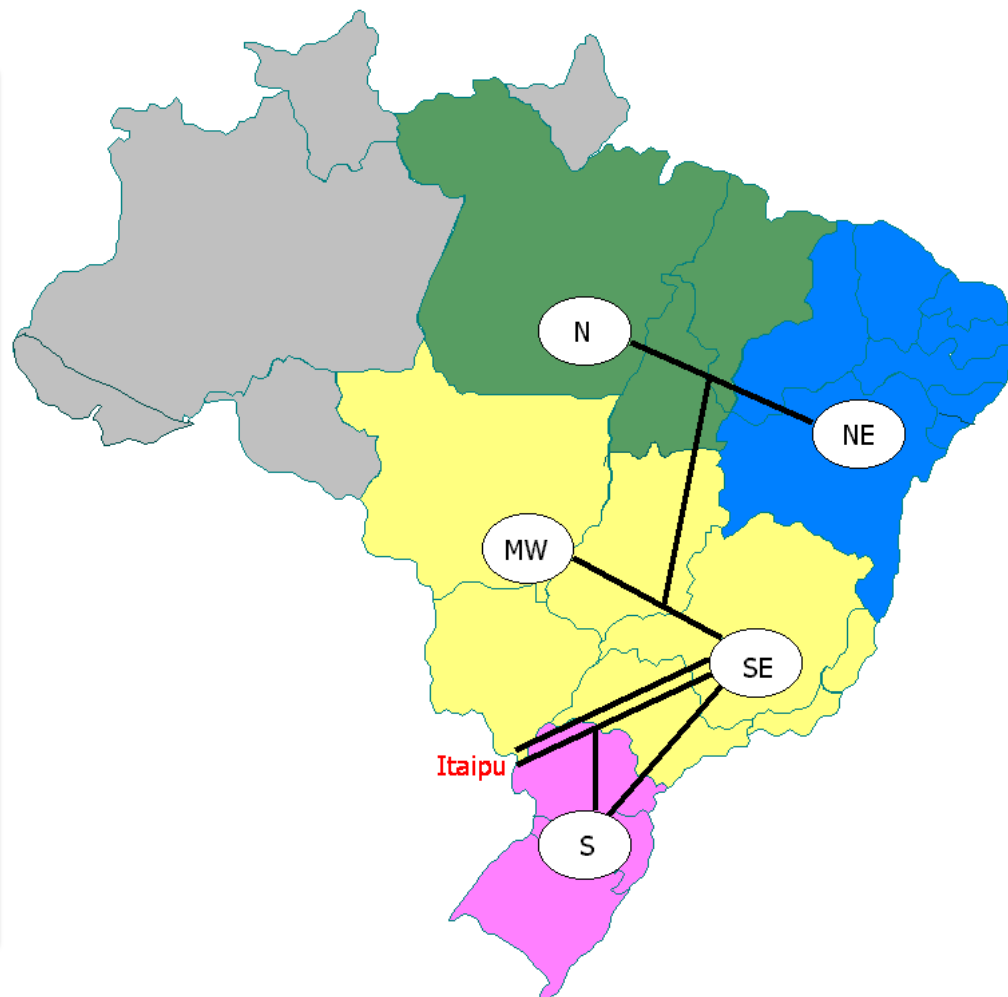
Consumption 500,000 GWh

Losses 15%

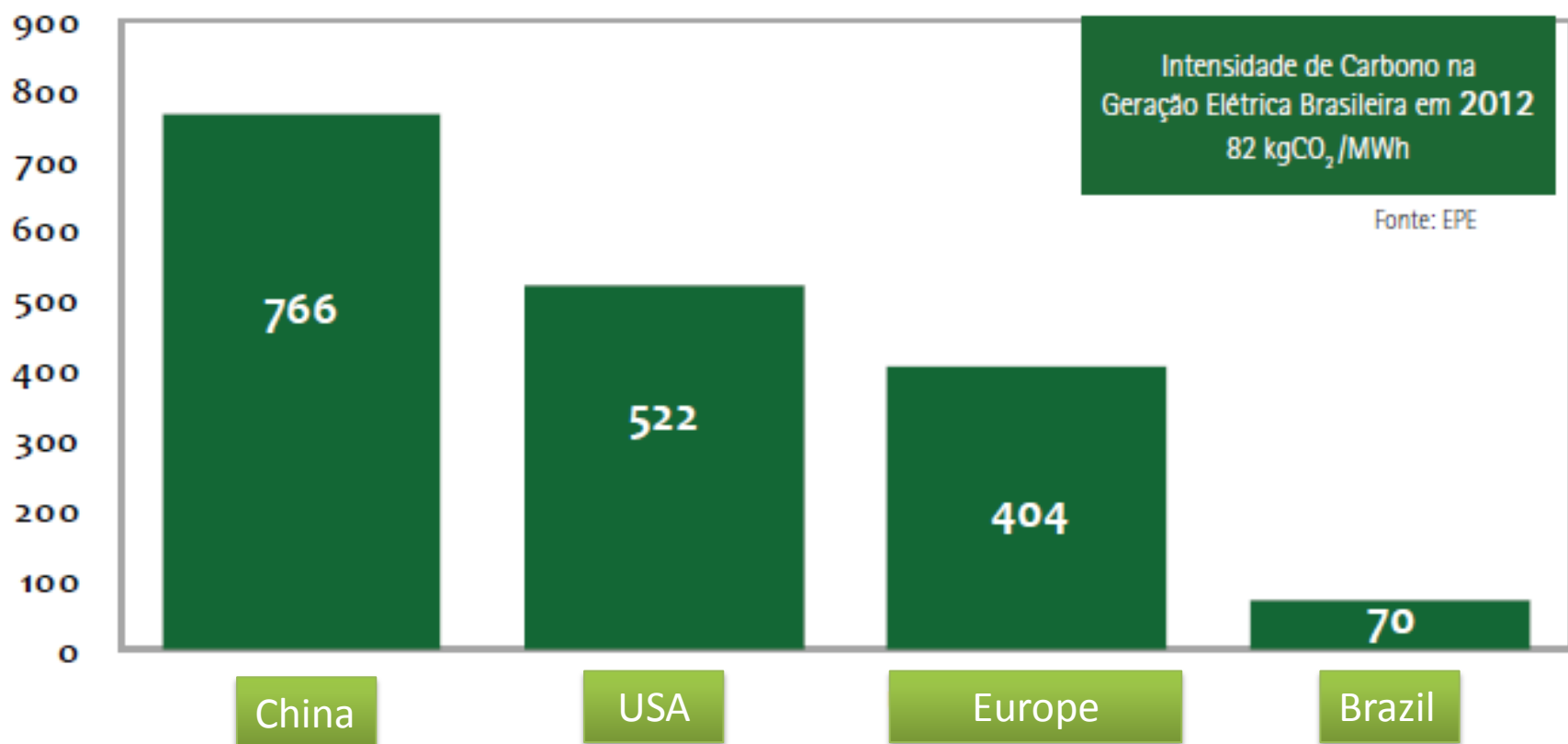
Hydroelectric energy 77%  
(few years ago, it was 90%!)

Brazil renewables  
(hydroelectric + wind power +  
sugar cane bagasse) 85%

World renewables 20%

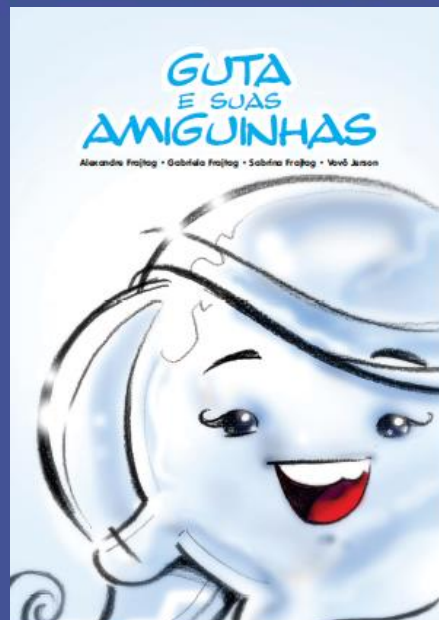


## Kg CO<sub>2</sub> / MWh (2010)

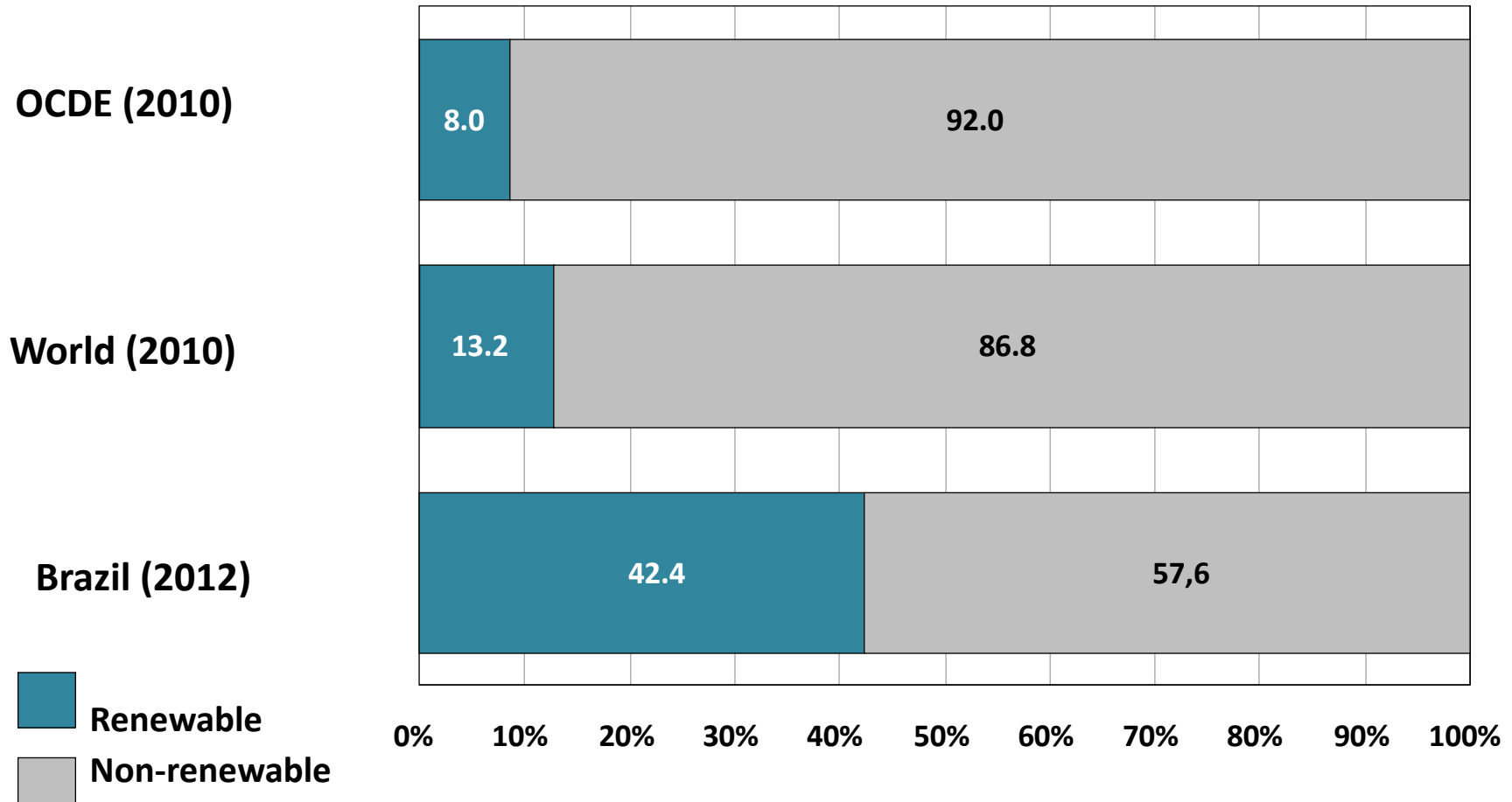


Fonte: Agência Internacional de Energia. (\*Fonte: EPE)

**WE HAVE BEEN PRODUCING ELECTRICITY FROM  
SOLAR ENERGY FOR MORE THAN A CENTURY**



# Overall use of Energy



In Brazil:

- electricity is mostly produced by water
- vehicles can use any blend of gas + ethanol (flex fuel)

## RENOVÁVEIS ▶ 42,4%

biomassa da cana  
15,4%



hidráulica e eletricidade  
13,8%



lenha e carvão vegetal  
9,1%



lixívia e outras renováveis  
4,1%



## NÃO RENOVÁVEIS ▶ 57,6%

petróleo e derivados  
39,2%



gás natural  
11,5%



carvão mineral  
5,4%

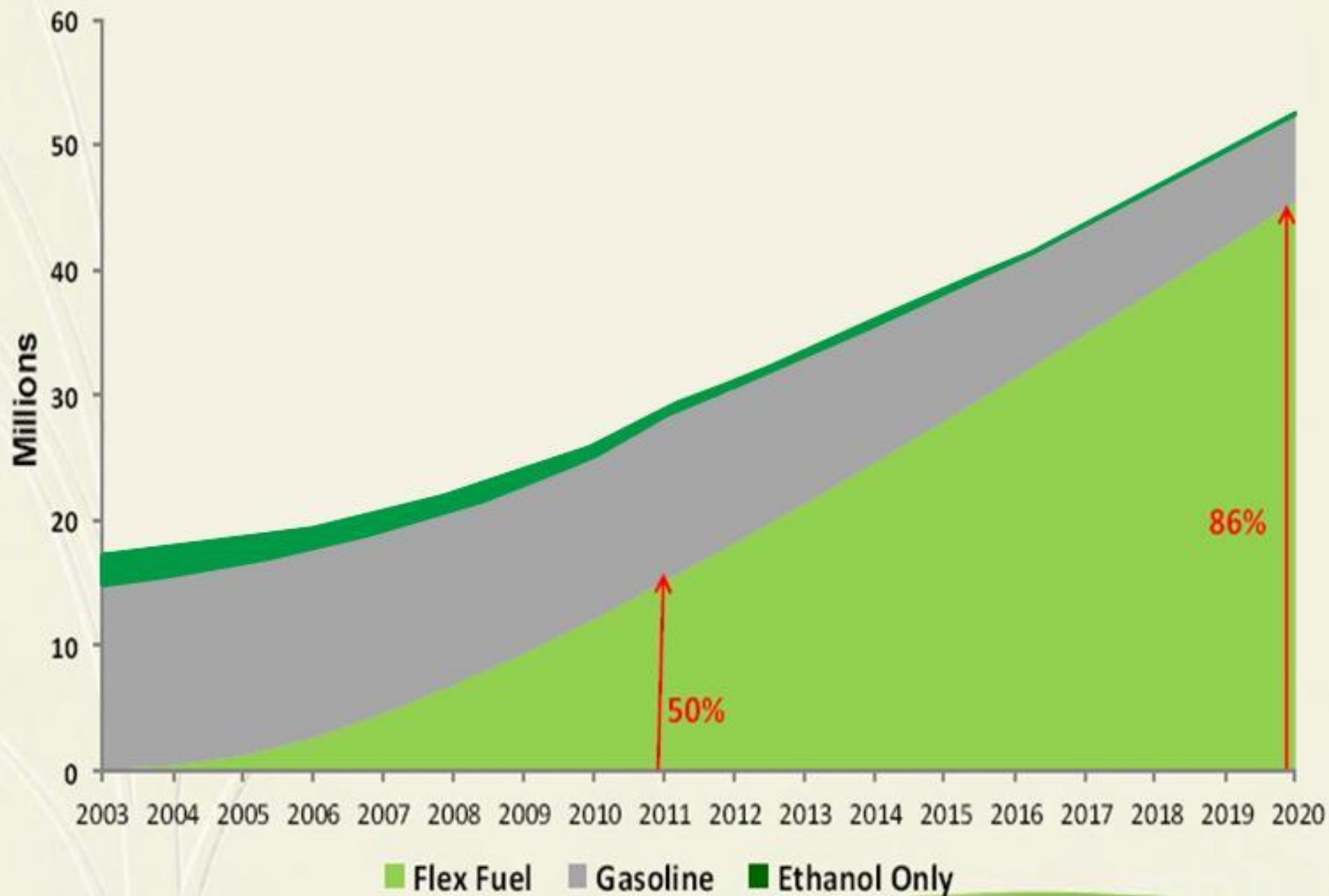


urânio  
1,5%



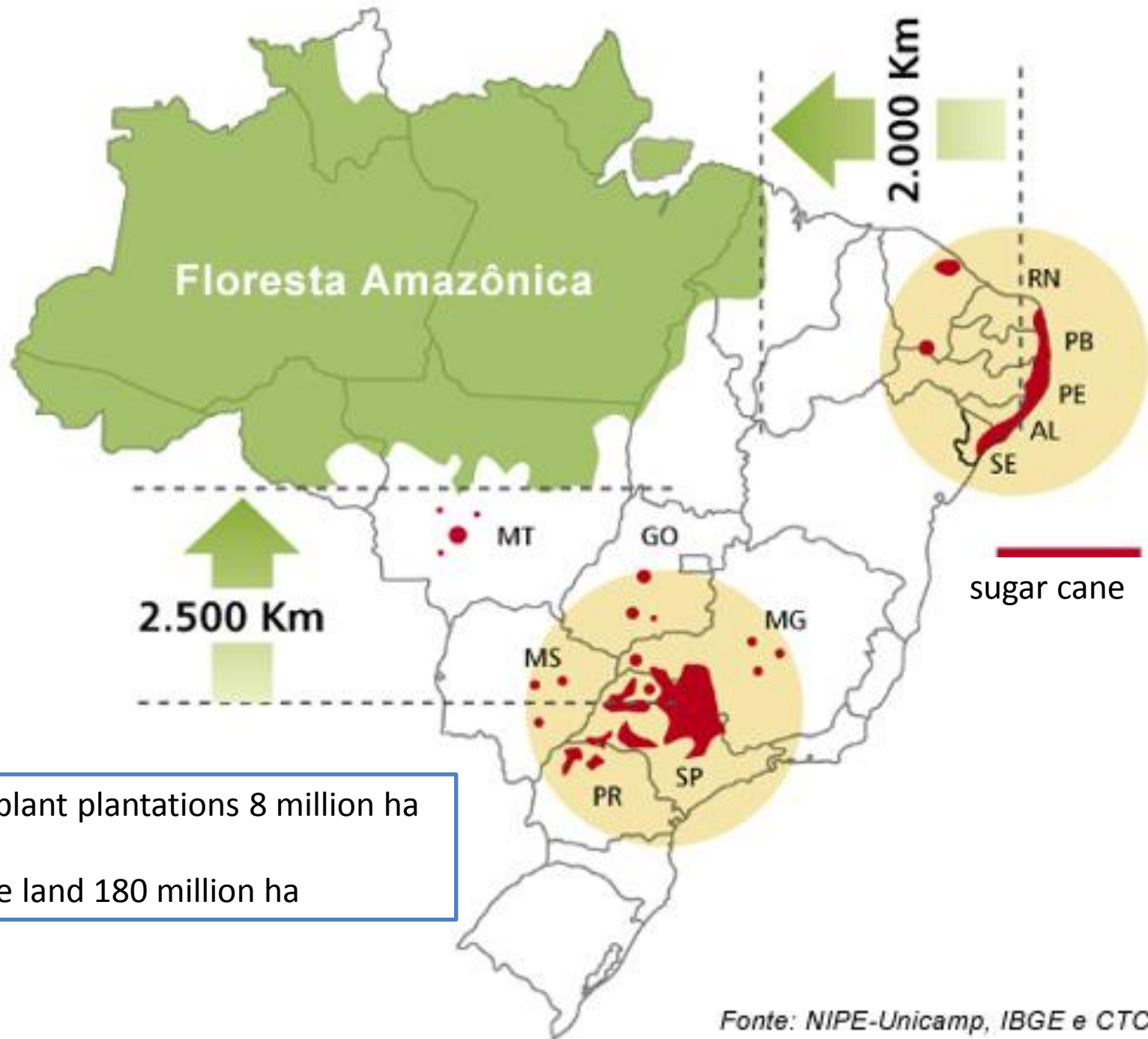


# Light vehicles in Brazil



Blending sugarcane ethanol to gasoline is a proved and easy way to decrease overall emission of GHG

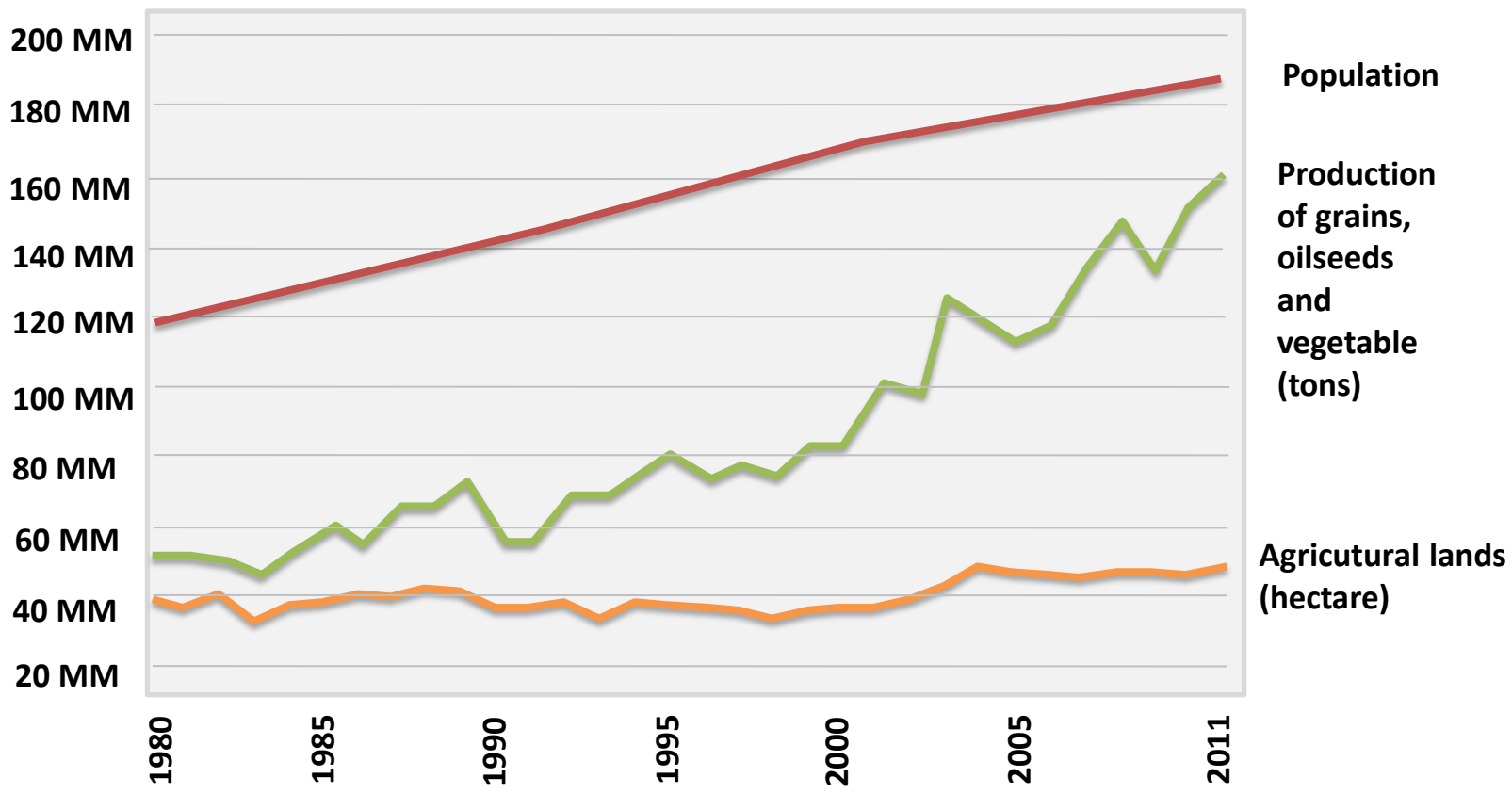
But... would sugarcane expansion affect food security or the environment?



Sugar plant plantations 8 million ha

Pasture land 180 million ha

# Brazilian Agricultural Evolution



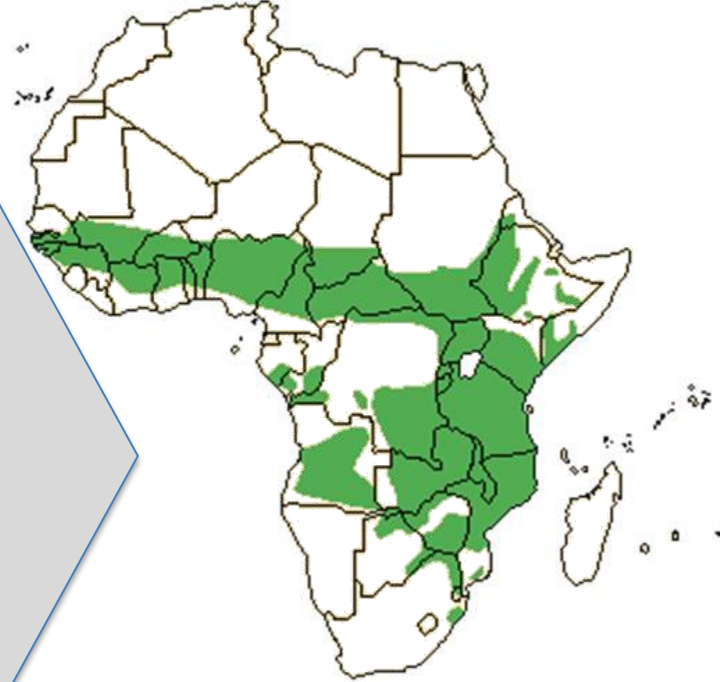


# South – South: “Brazilian Savannah” to African Savannah

Cerrado: “Brazilian Savannah”



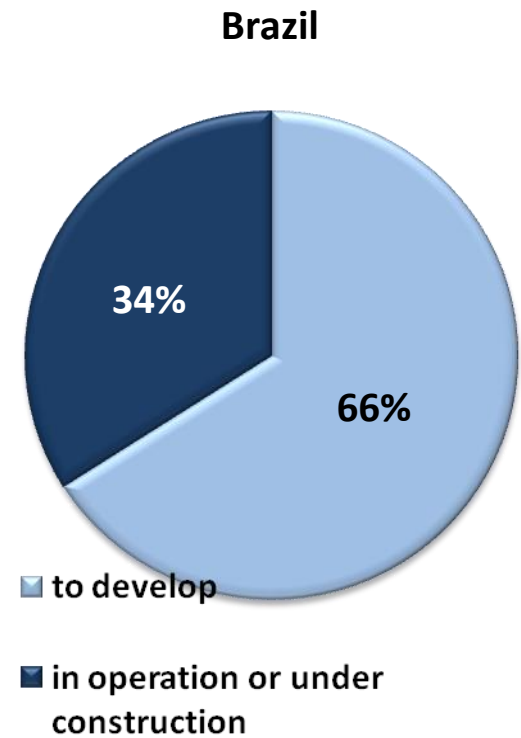
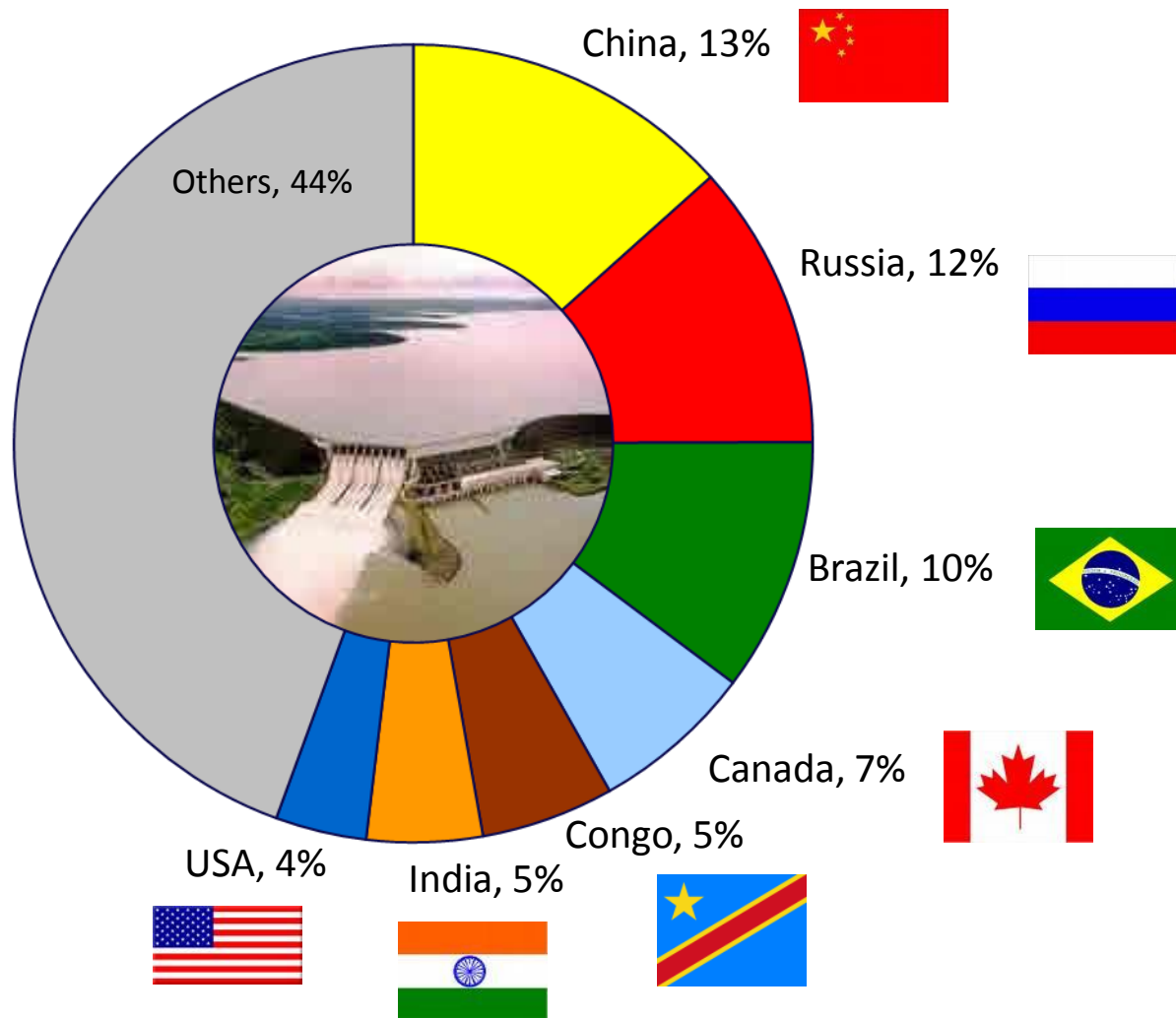
“African Savannah”



## Same conditions

- Acid Soil
- Low fertility
- High temperatures

# Hydropower possibilities





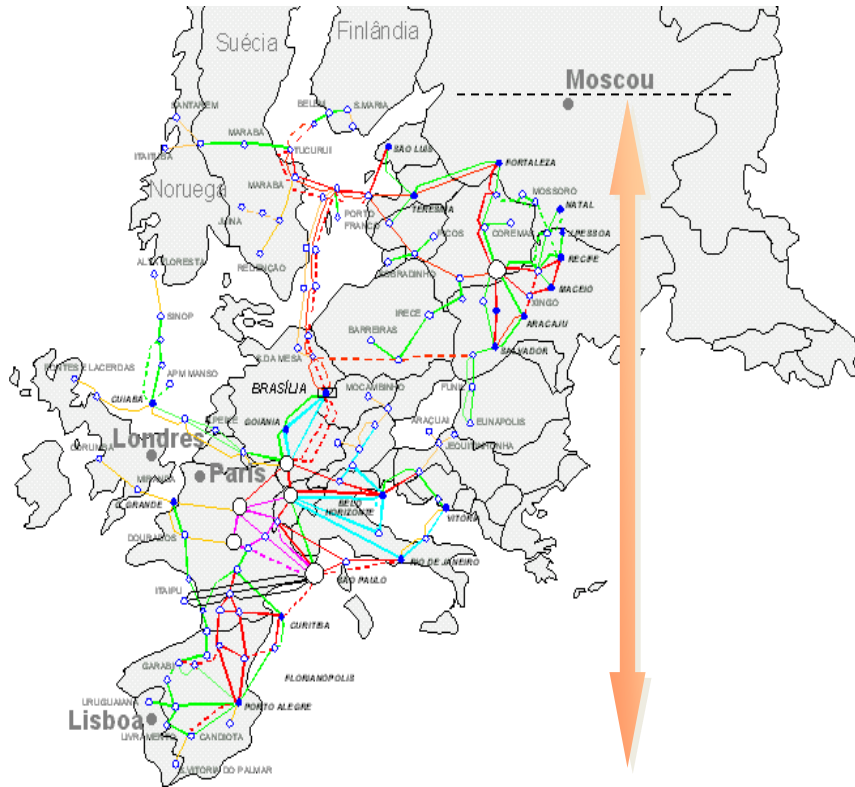
Brazilian  
population  
~190 million

**Brazil**  
8.5 million km<sup>2</sup>



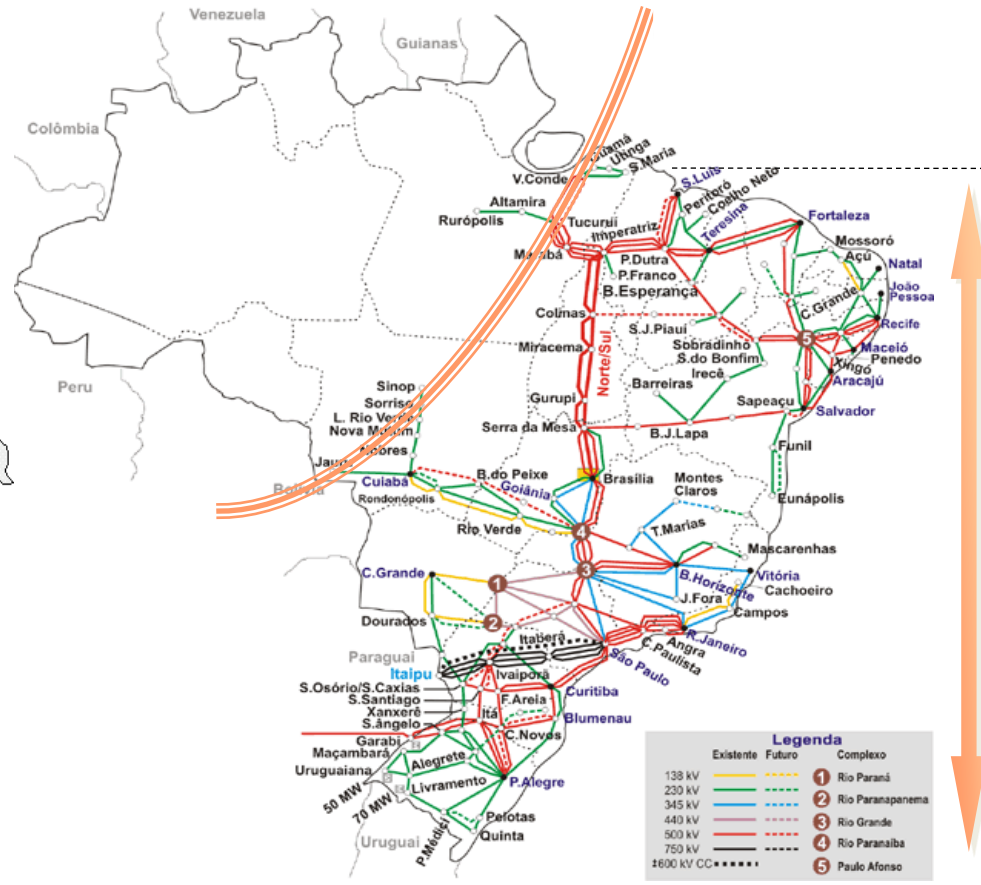
# Transmission System

## 120.000 km 230 -800 kV



Europe

4 000 km



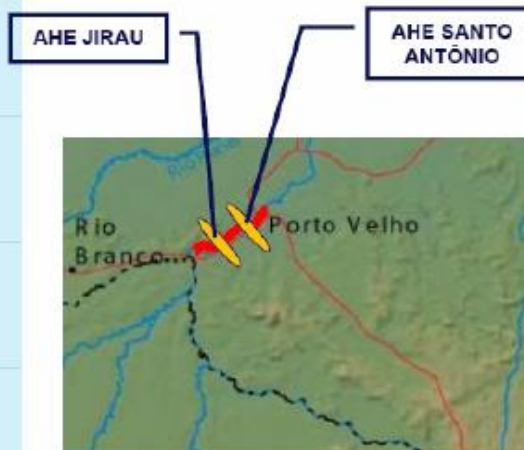
Brazil

4 000 km



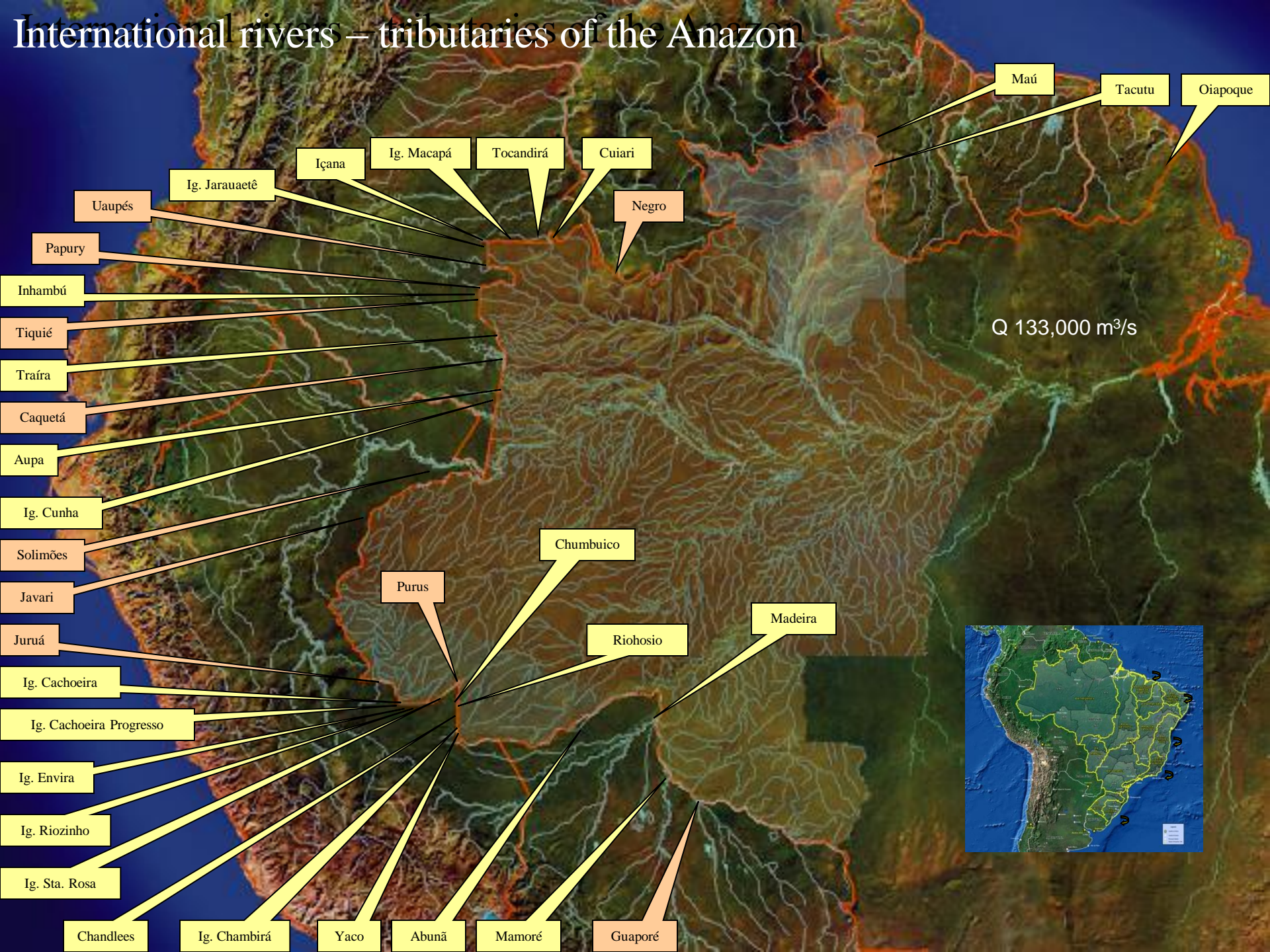
# Does it make sense to build new hydro plants in the Amazon?

## THE MADEIRA RIVER PROJECT



What would be the alternatives?





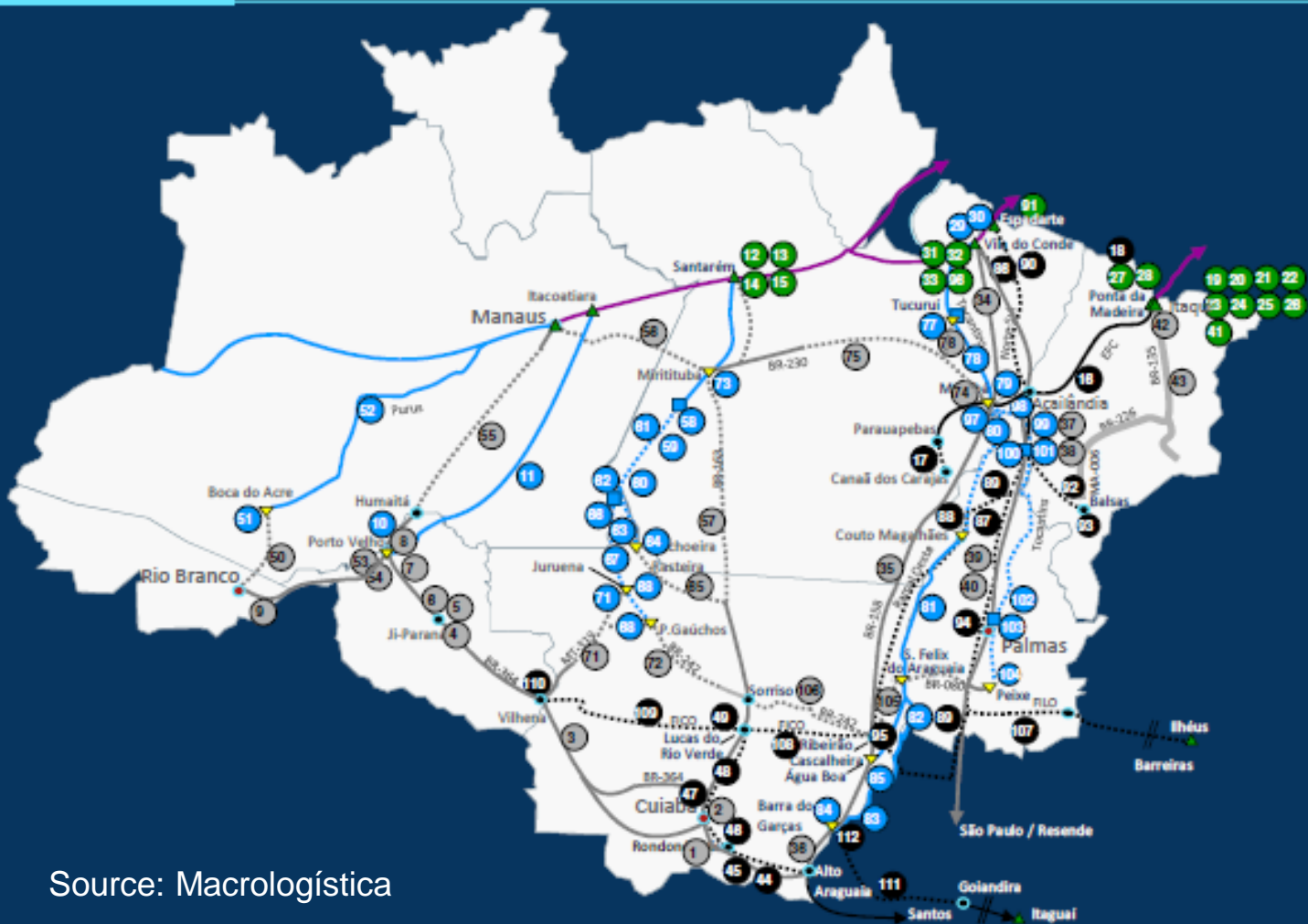
Does it make sense to build new waterways to integrate South America countries?



Source: Macrologística



Does it make sense to build new waterways (mostly for transportation of grains) in the Brazilian Amazon?





# When deciding about a new infrastructure project...

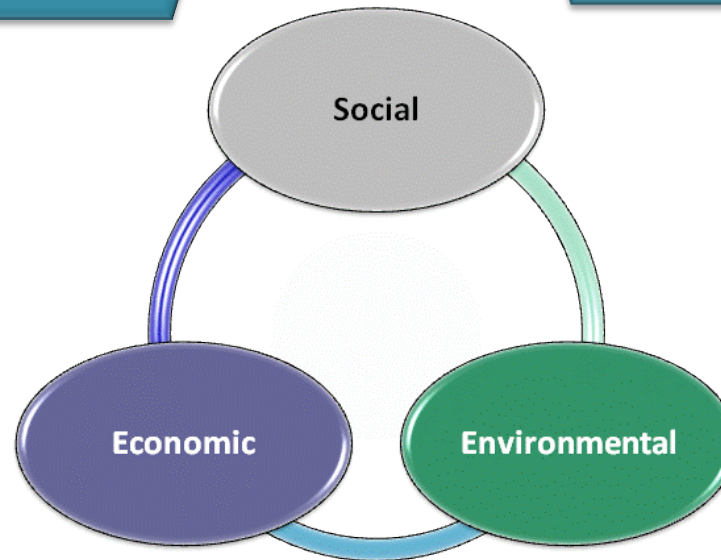
**What happens if the  
plant is built?**

**What happens if the  
plant isn't built**

**Local impacts**

**X**

**Global impacts**



Many believe that there are no trade-offs:  
hydropower plants should not be built.  
Period.



James Cameron and Sigourney Weaver  
campaigning against the construction of  
Belo Monte hydropower plant



## **Hydropower for Me But Not for Thee, 3/6/14**

[John Briscoe](#)

[Global Development: Views from the Center](#)  
[Energy, energy access](#)

Senator Patrick Leahy of Vermont included in the Consolidated Appropriations Act of 2014:

The Secretary of the Treasury shall instruct the United States executive director of each international financial institution that it is the policy of the United States to oppose any loan, grant, strategy or policy of such institution to support the construction of any large hydroelectric dam.”

Briscoe:

On his [website](#) Senator Leahy states: “Vermont has 84 operating hydroelectric plants, with a total generating capacity of 190 megawatts, and also draws a large portion of its energy portfolio from hydropower facilities operated by Hydro Quebec...”



Out of the 20 million Brazilians that live in the Amazon, 200 thousand (1%) live in reserved areas.



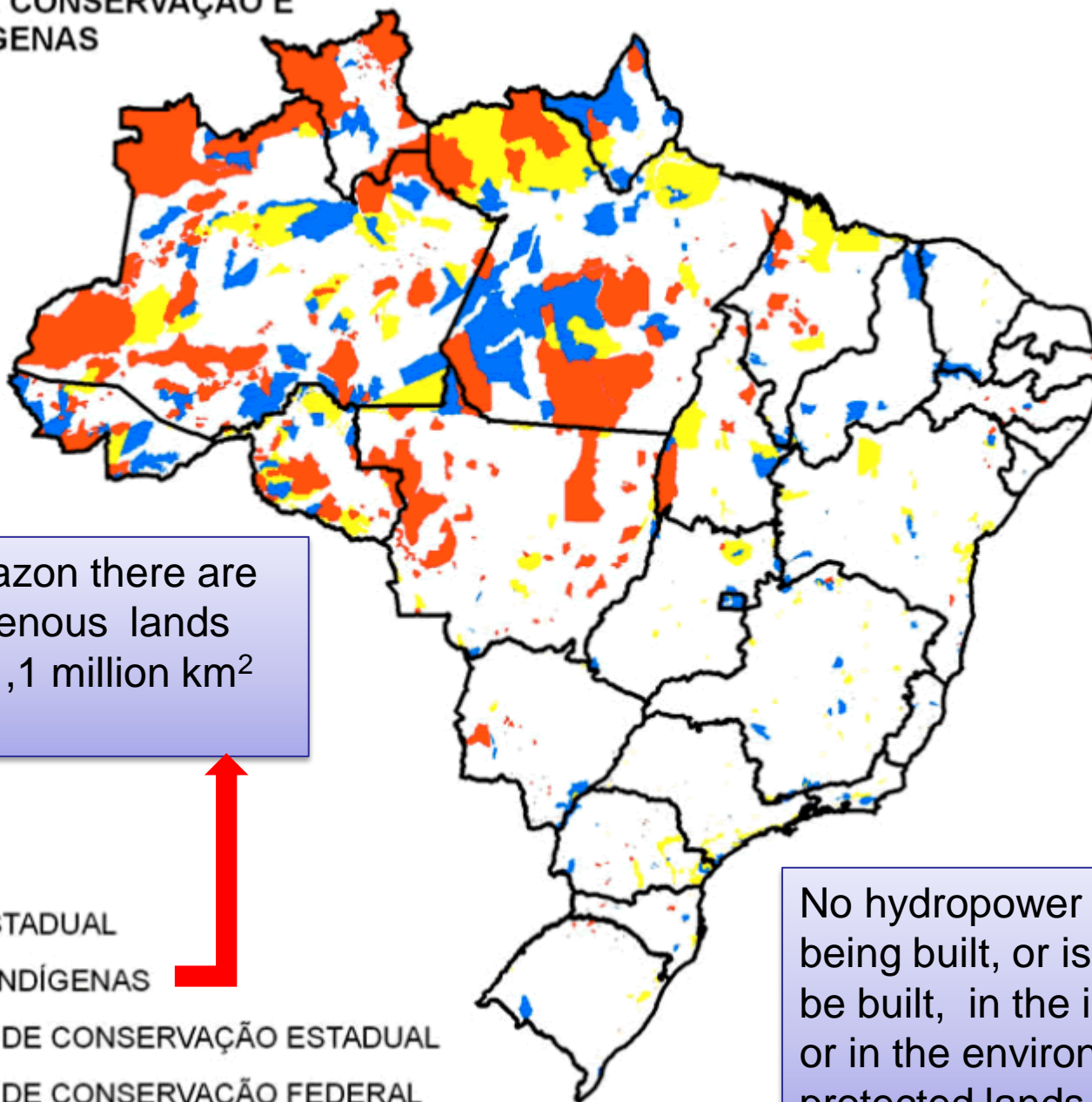


## UNIDADES DE CONSERVAÇÃO E TERRAS INDÍGENAS

Embrapa  
Monitoramento por Satélite





Ministério da  
Agricultura, Pecuária  
e Abastecimento

BRASIL  
UM PAÍS DE TODOS  
GOVERNO FEDERAL

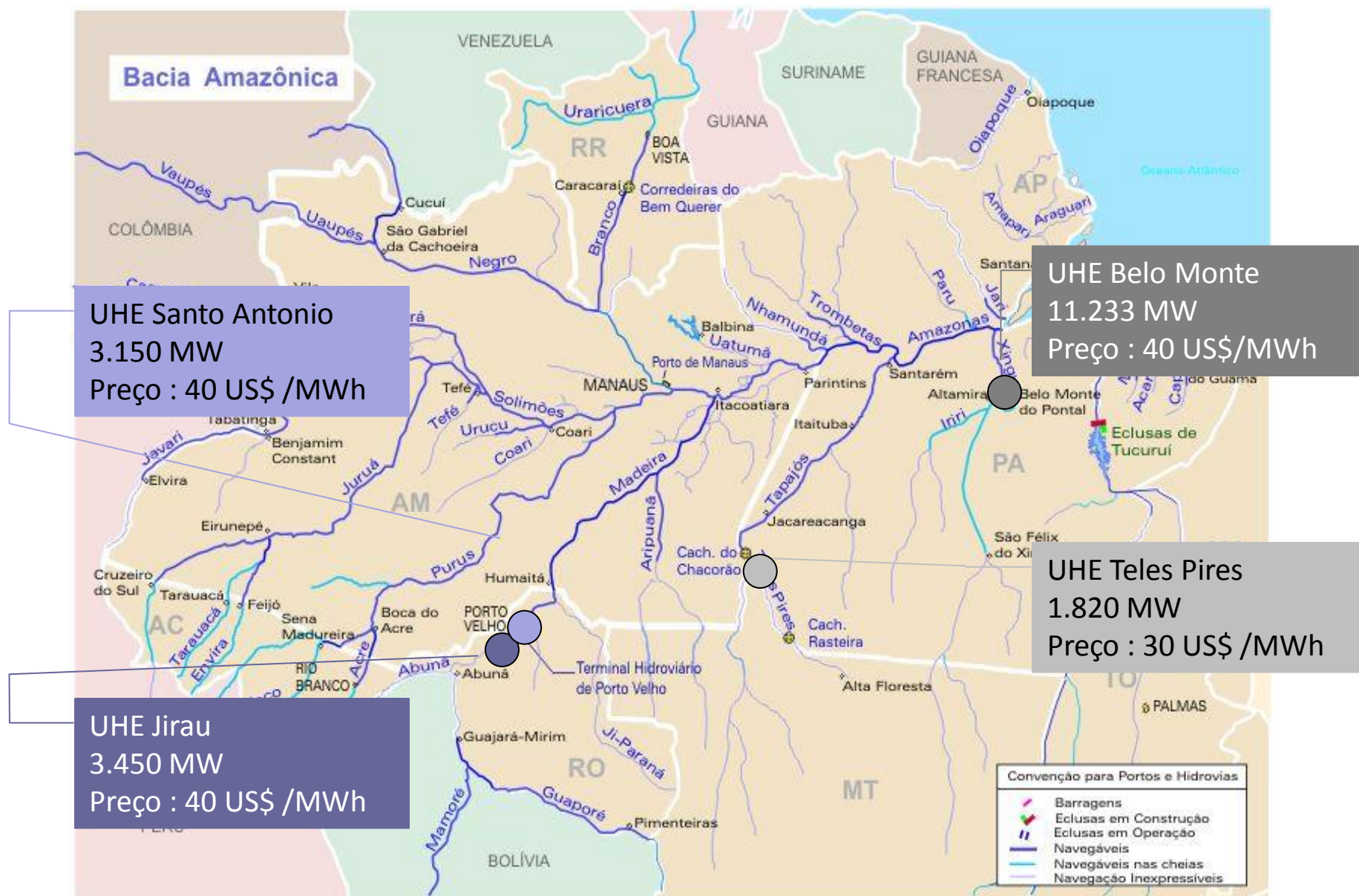


In the Amazon there are  
414 indigenous lands  
covering 1,1 million km<sup>2</sup>  
(4 X UK)

### Legenda

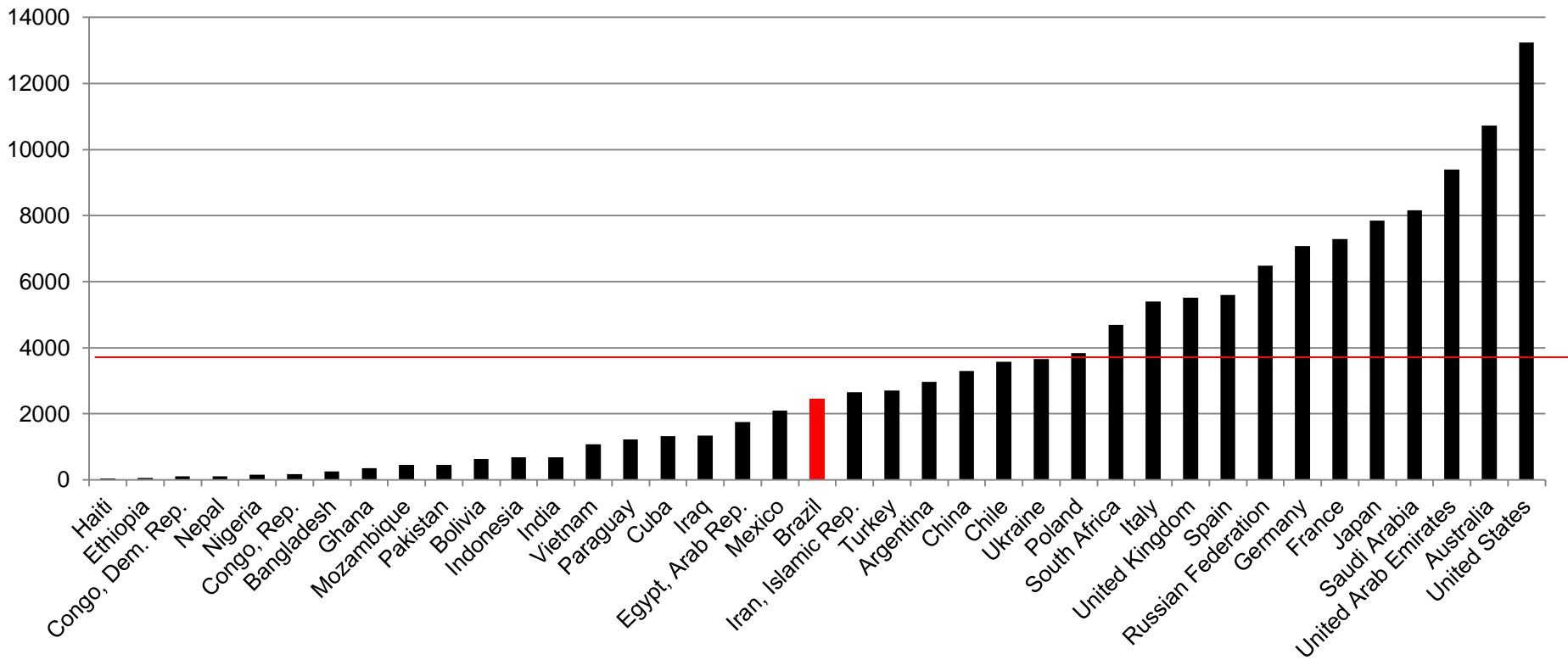
-  DIVISA ESTADUAL
-  TERRAS INDÍGENAS
-  UNIDADE DE CONSERVAÇÃO ESTADUAL
-  UNIDADE DE CONSERVAÇÃO FEDERAL

No hydropower plant is  
being built, or is planned to  
be built, in the indigenous  
or in the environmentally  
protected lands



# Per capita consumption of electricity (kWh/year) 2011

Source: The World Bank



## Relationship between storage and monthly consumption

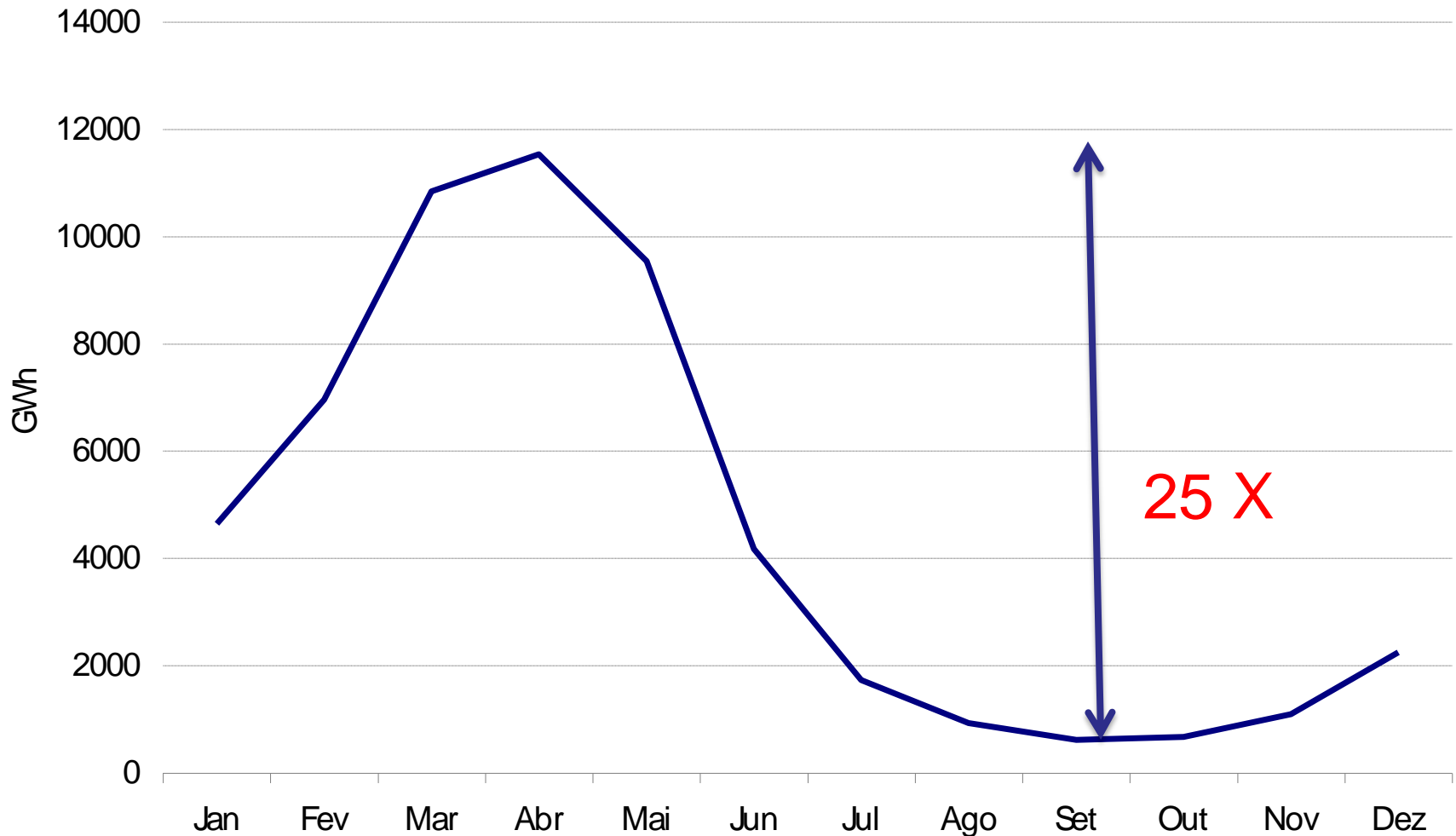


FONTE: EPE.

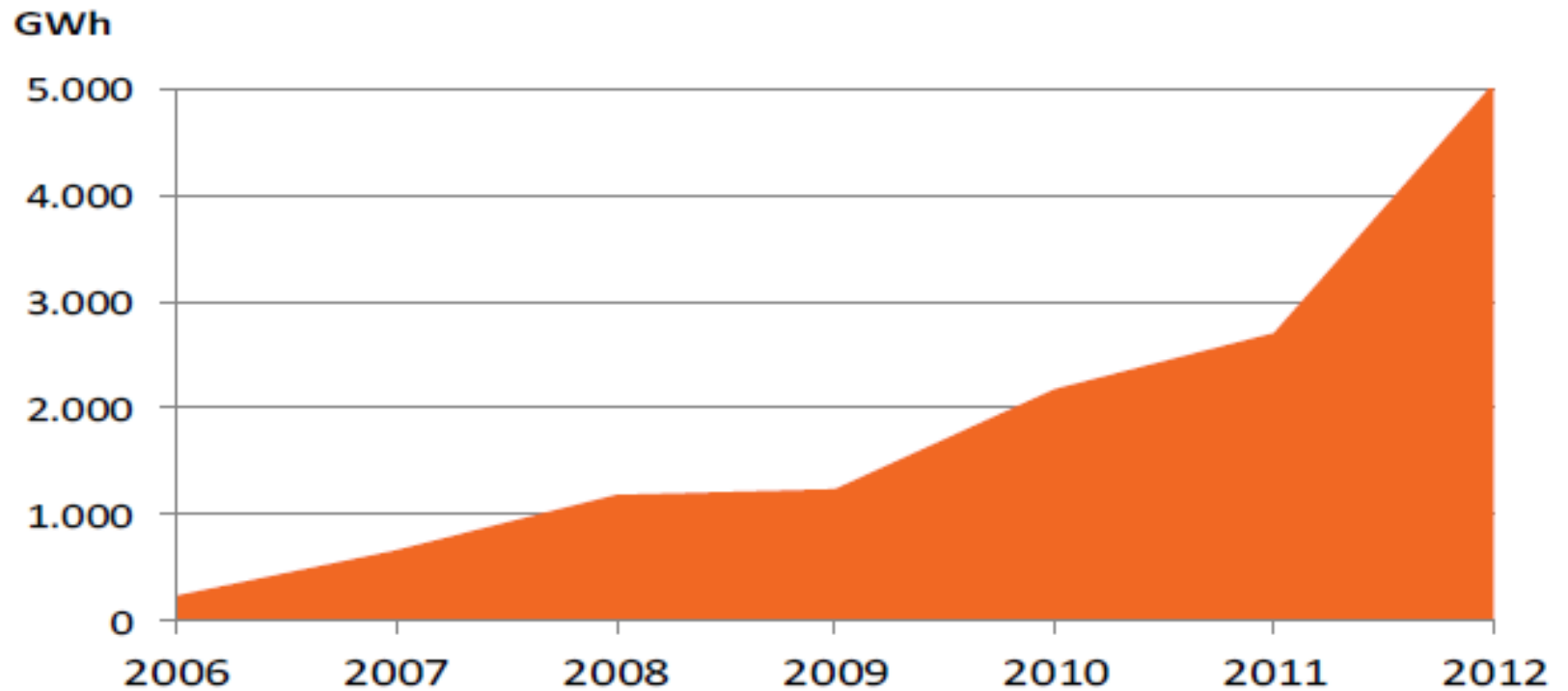
Tolmasquim (EPE) - Enase 2010



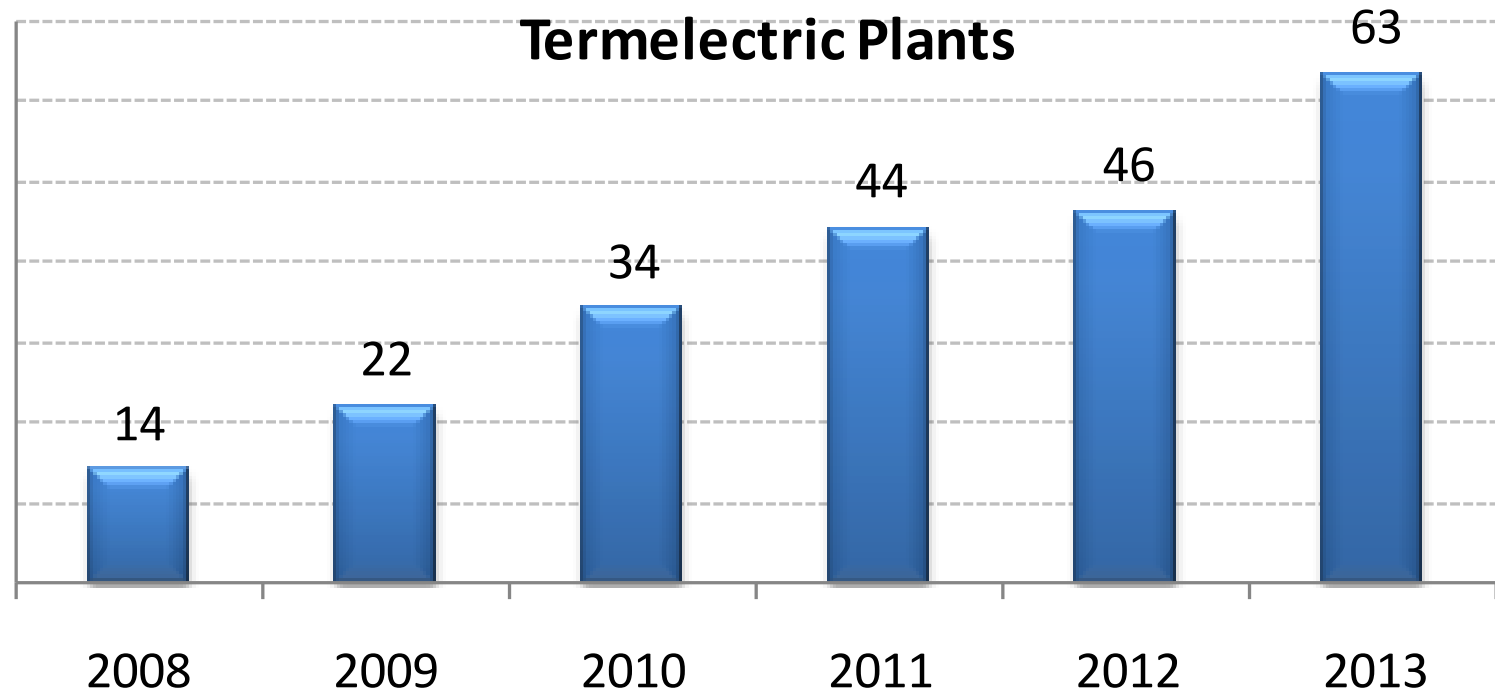
# Streamflow variability of the future Belo Monte power plant



## Why wind power is economically competitive in Brazil?

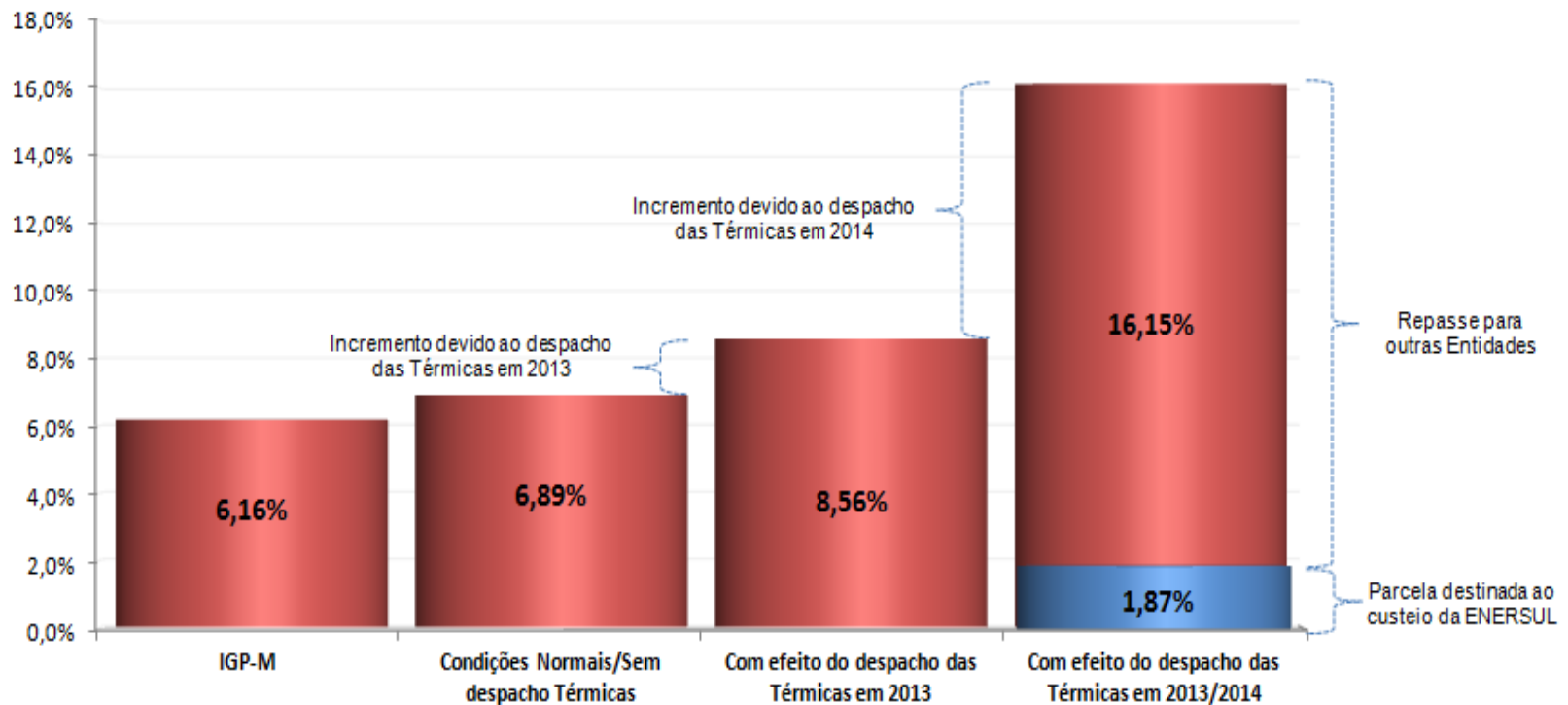


What happened in Brazil when environmental licenses for hydropower projects were denied or disputed in court?



# Explaining to the consumer the rise of electric energy tariff

## Efeitos no Índice de Reajuste Tarifário - ENERSUL-2014



Condições Normais: Reajuste econômico sem variações de preços da energia no período;

Efeito despacho das Térmicas 2013: Reajuste considerando os efeitos financeiros da variação de preços da energia em 2013;

Efeito despacho das Térmicas 2013/2014: Reajuste considerando os efeitos financeiros da variação de preços da energia em 2013 e a projeção de preços de energia para 2014 (PLD);



About 5% of the Brazilian population lives in the Northeast corner of the country. They share the same language, culture, institutions, education and political system of the other 95%. Yet, they have by far the lowest per capita income. What really differentiates this region from the rest of the country is hydrological variability. How to mitigate this problem?



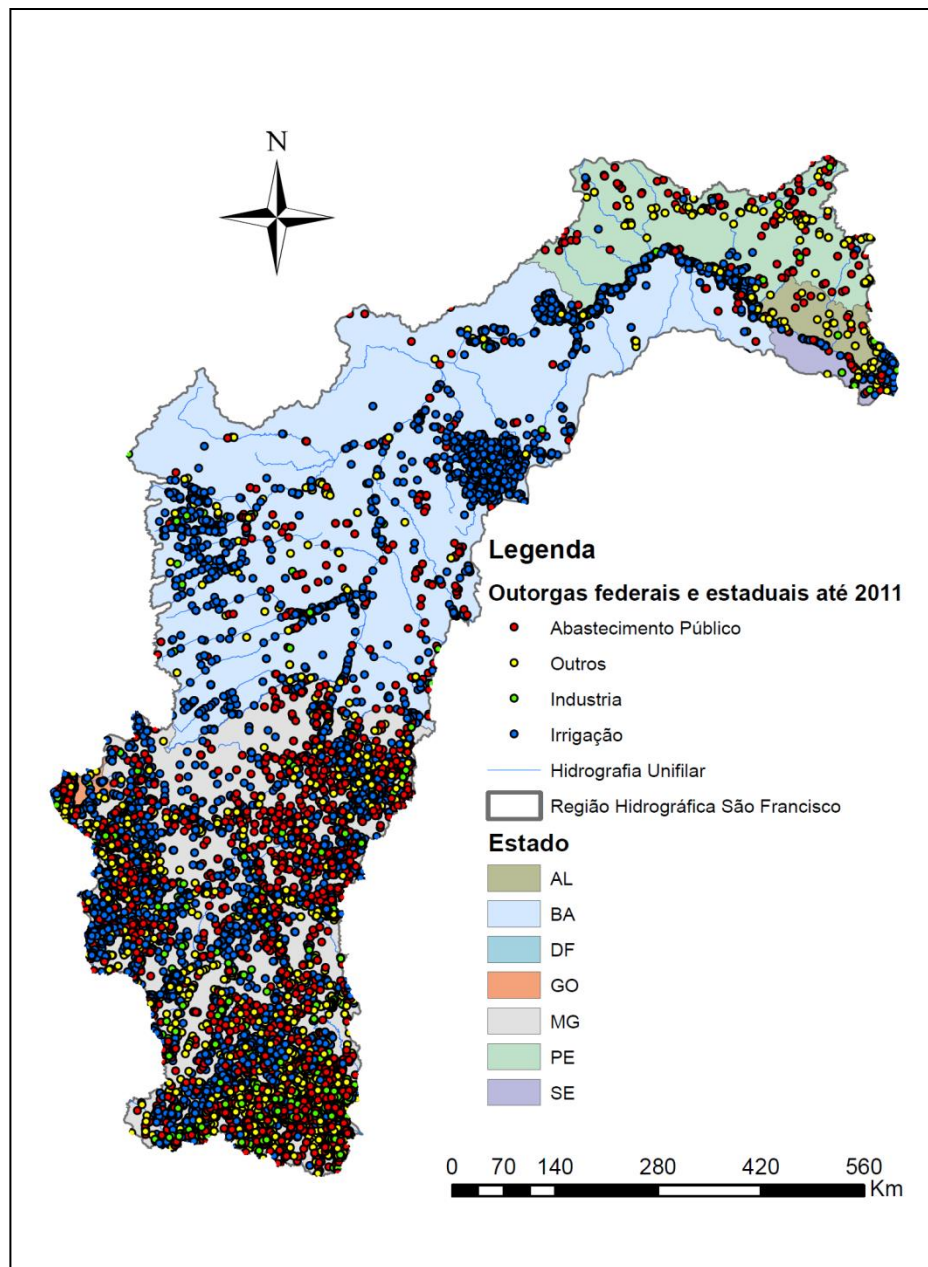
A topographic map of Brazil showing state boundaries in white. The São Francisco River Basin is highlighted in red, and the Sobradinho Reservoir is marked with a blue dot. Two callout boxes provide details about the reservoir and the basin. A dark blue box in the bottom left corner contains the word 'Brazil'.

**Brazil**

Sobradinho  
Reservoir  
34 billion m<sup>3</sup>

Sao Francisco  
River Basin  
2800 m<sup>3</sup>/s  
640,000 km<sup>2</sup>  
Length 2600 km

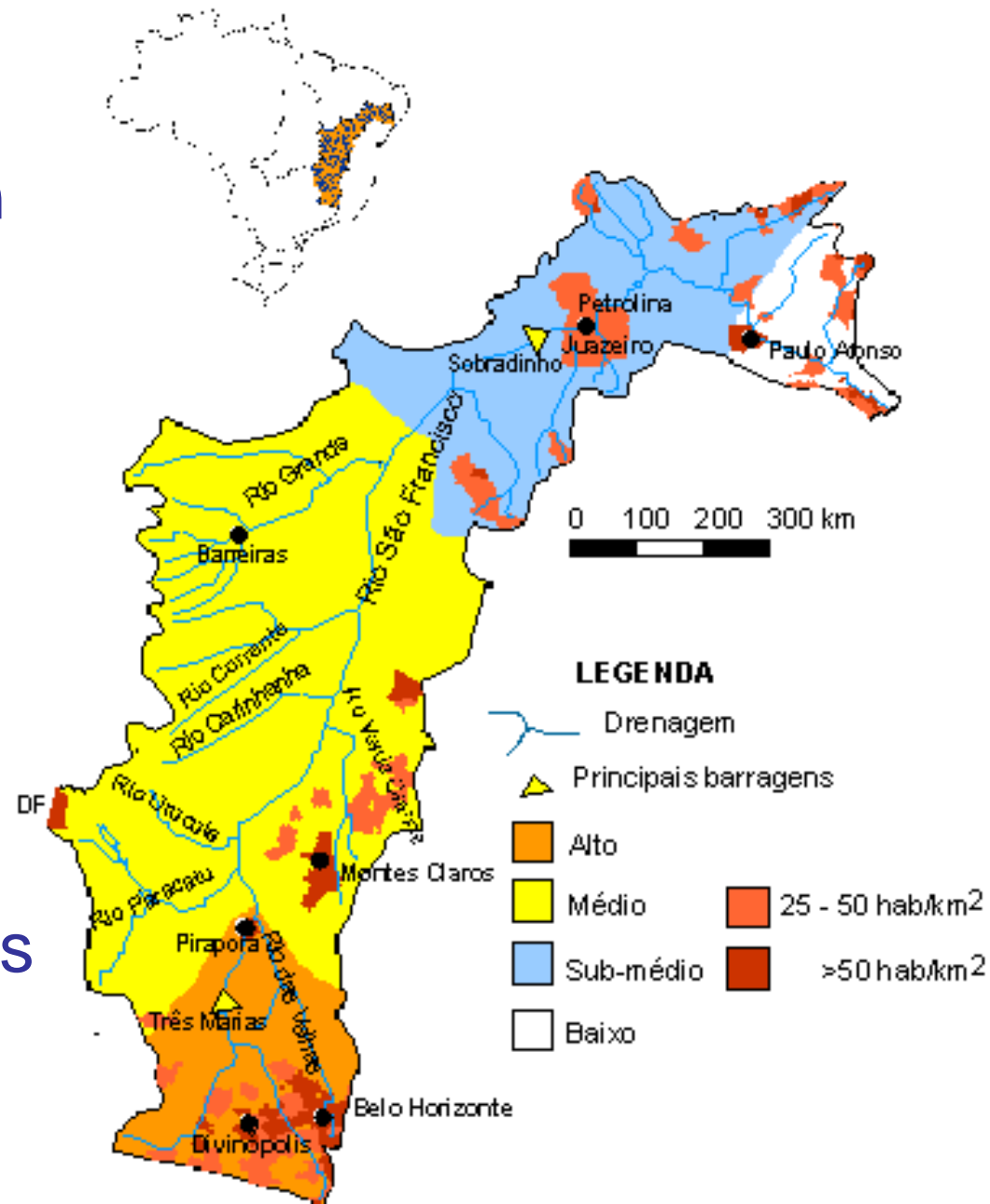
# Water rights





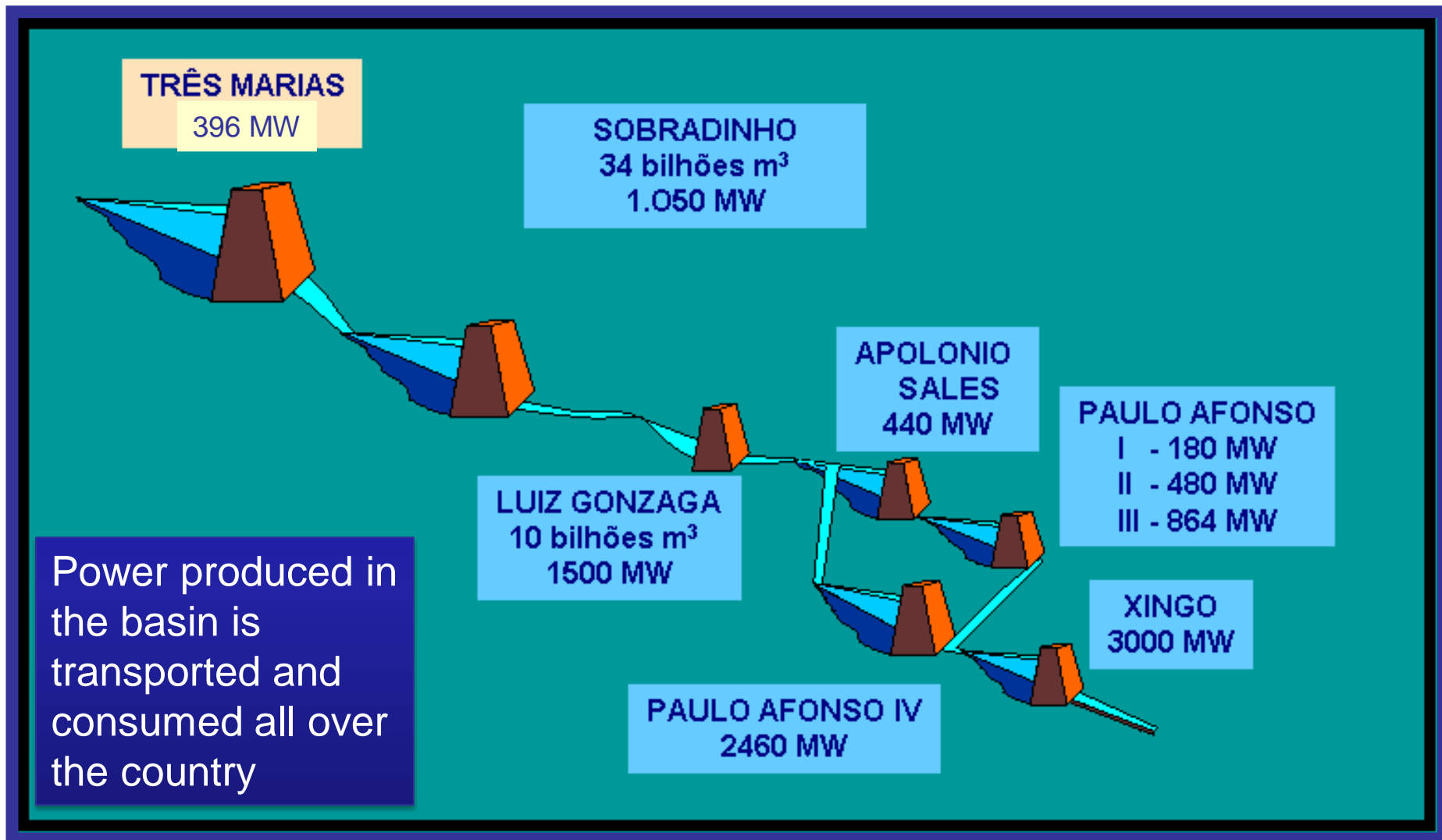
# The San Francisco river basin plan was approved by the basin committee

- investment plan (sewage collection and treatment, storage, reforestation...)
- criteria for allocating non tradable water rights
- criteria for pricing water rights

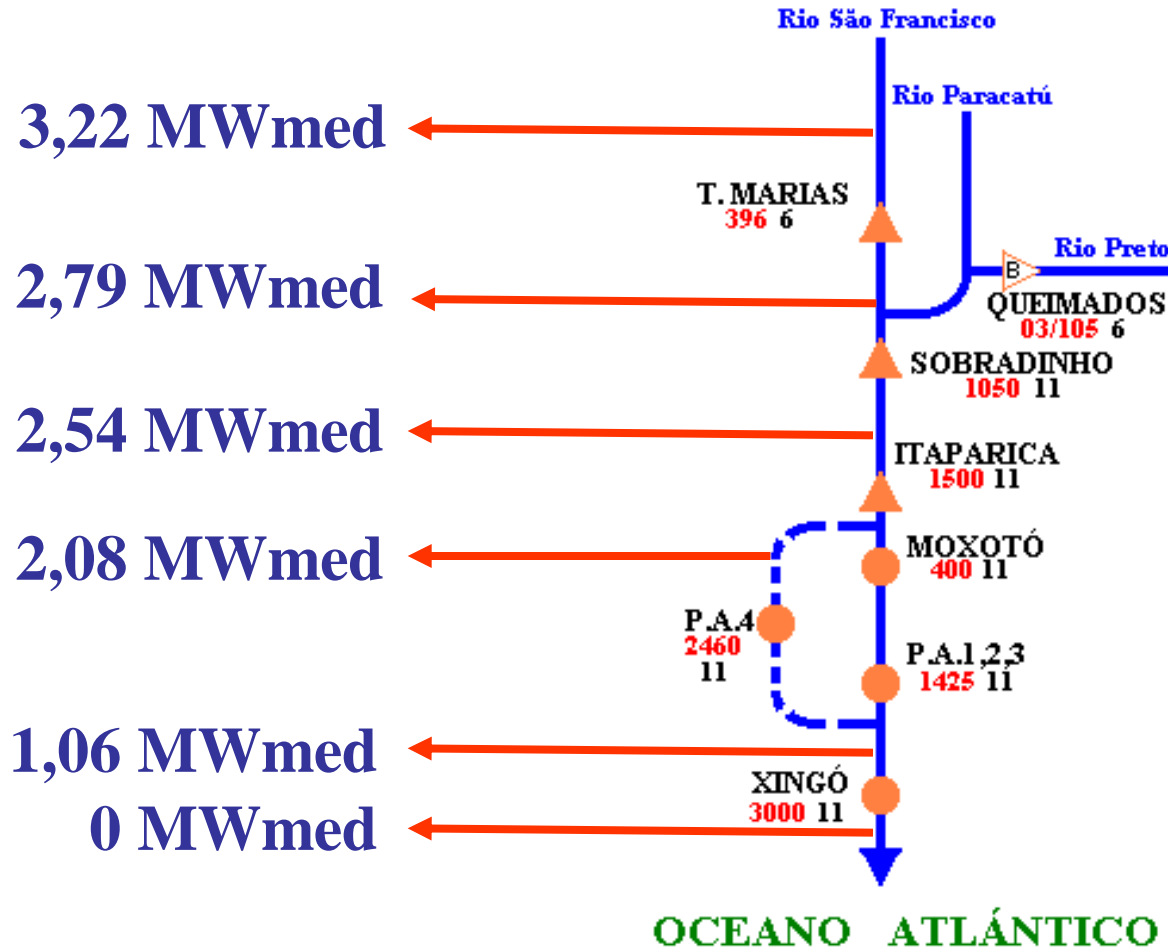




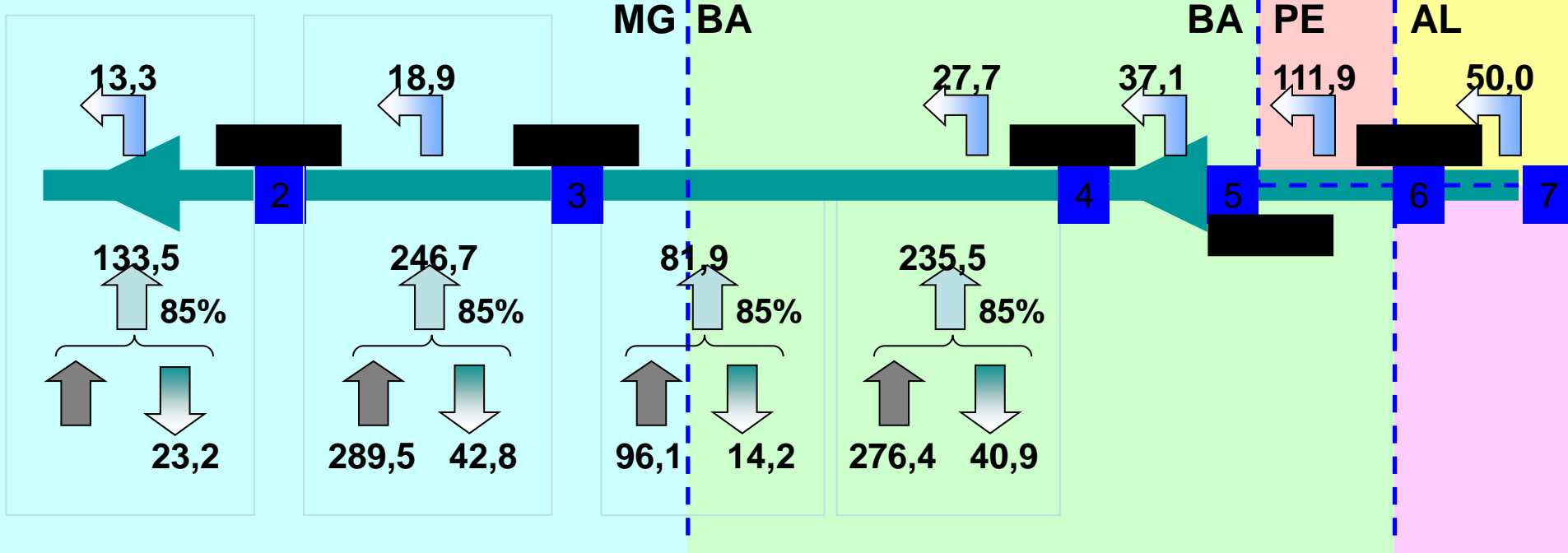
# Hydropower in the San Francisco River



# Irrigation X Hydropower



**Estimated  
decrease of  
firm power for  
each 1m<sup>3</sup>/s  
used in  
irrigation**



Water allocation among  
the states that share the  
San Francisco river basin

Mid river irrigation

X

Lower river hydropower

X

Inter basin water transfer



**Brazil**

Drought prone  
area

Sobradinho  
Reservoir  
34 billion m<sup>3</sup>

Sao Francisco  
River Basin  
2800 m<sup>3</sup>/s  
640,000 km<sup>2</sup>  
Length 2600 km



# Brazilian Semi-Arid

Intermittent rivers

Many small reservoirs that dry out during droughts

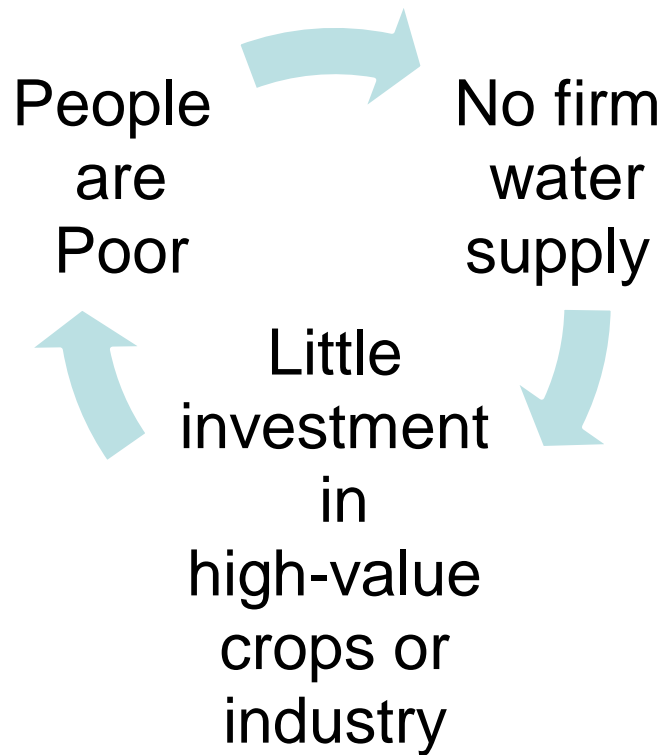
10 million people without reliable water supply



**3 km average  
distance to water  
sources**



# HYDROLOGICAL VICIOUS CYCLE

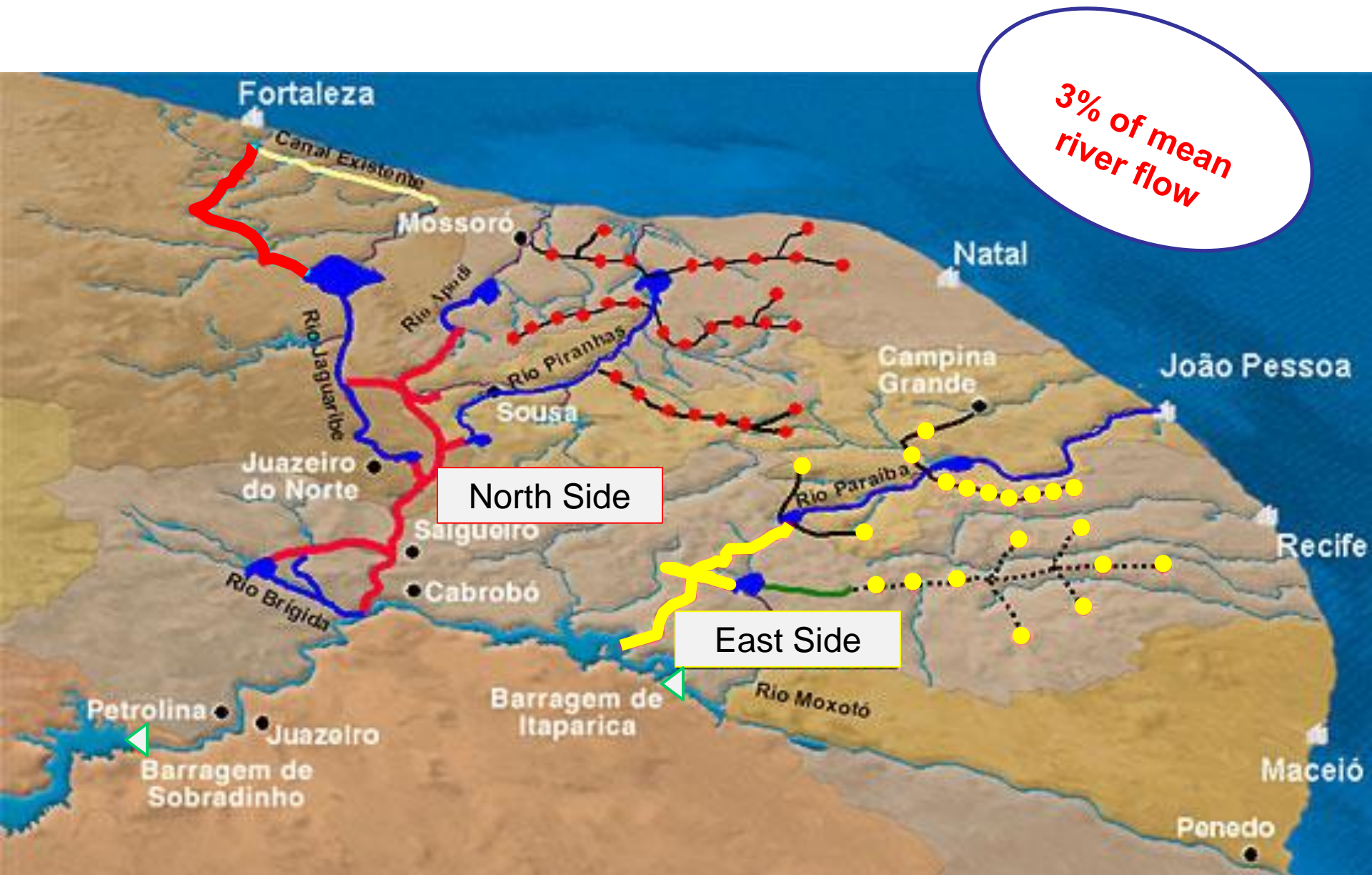


*It is necessary an initial stock of investments on water infrastructure before reaching the “inflexion point... and then real progress starts*

(David Grey and Claudia Sadoff, “Sink or Swim? Water security for growth and development”)

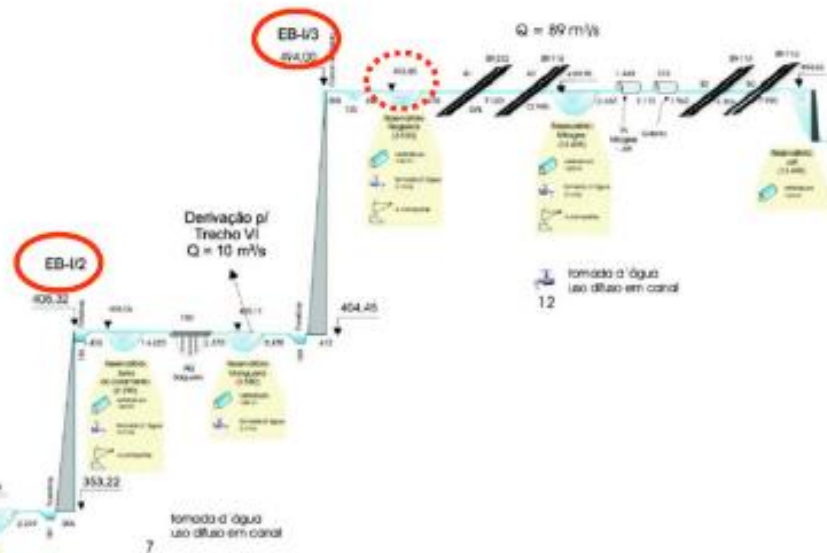
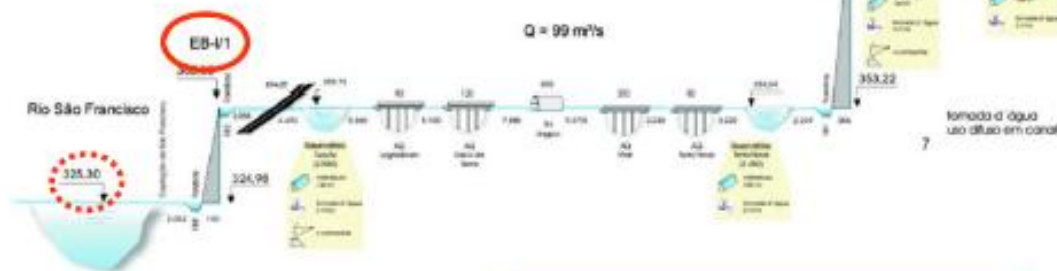


# San Francisco River Water Diversion

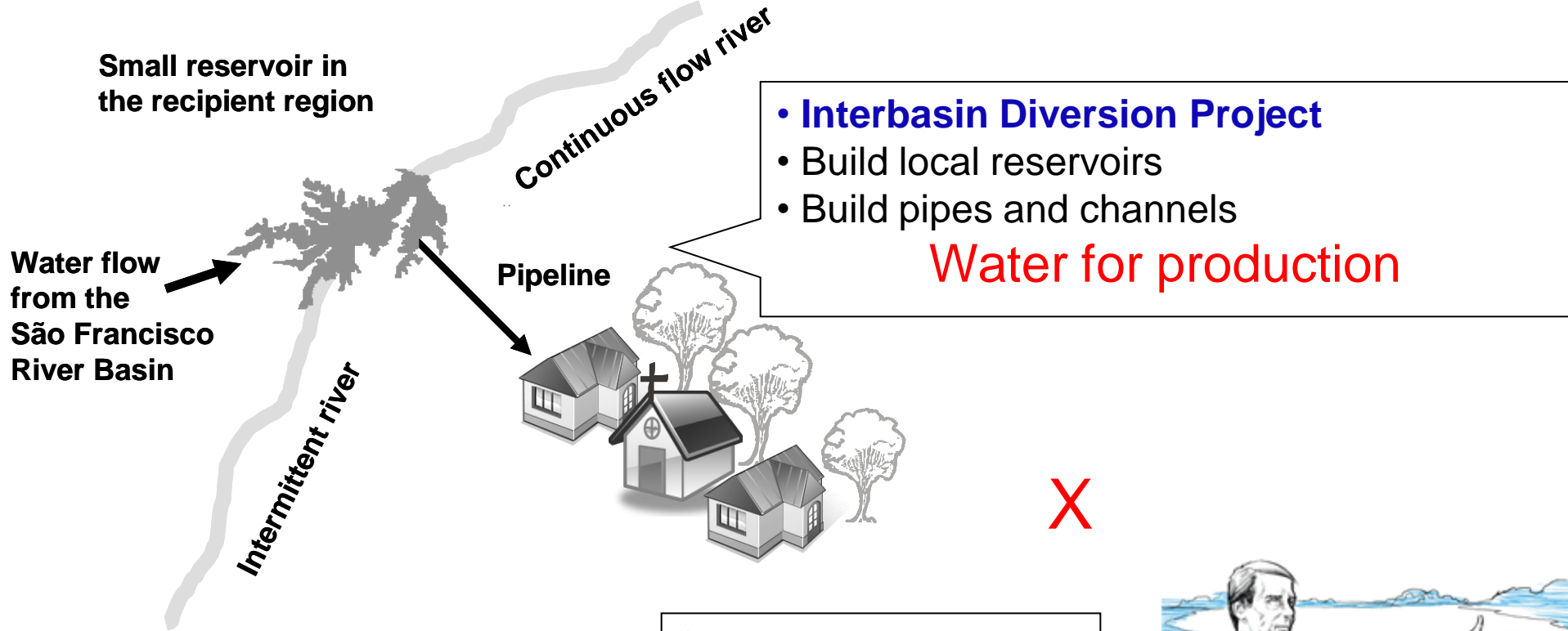




**EIXO NORTE**







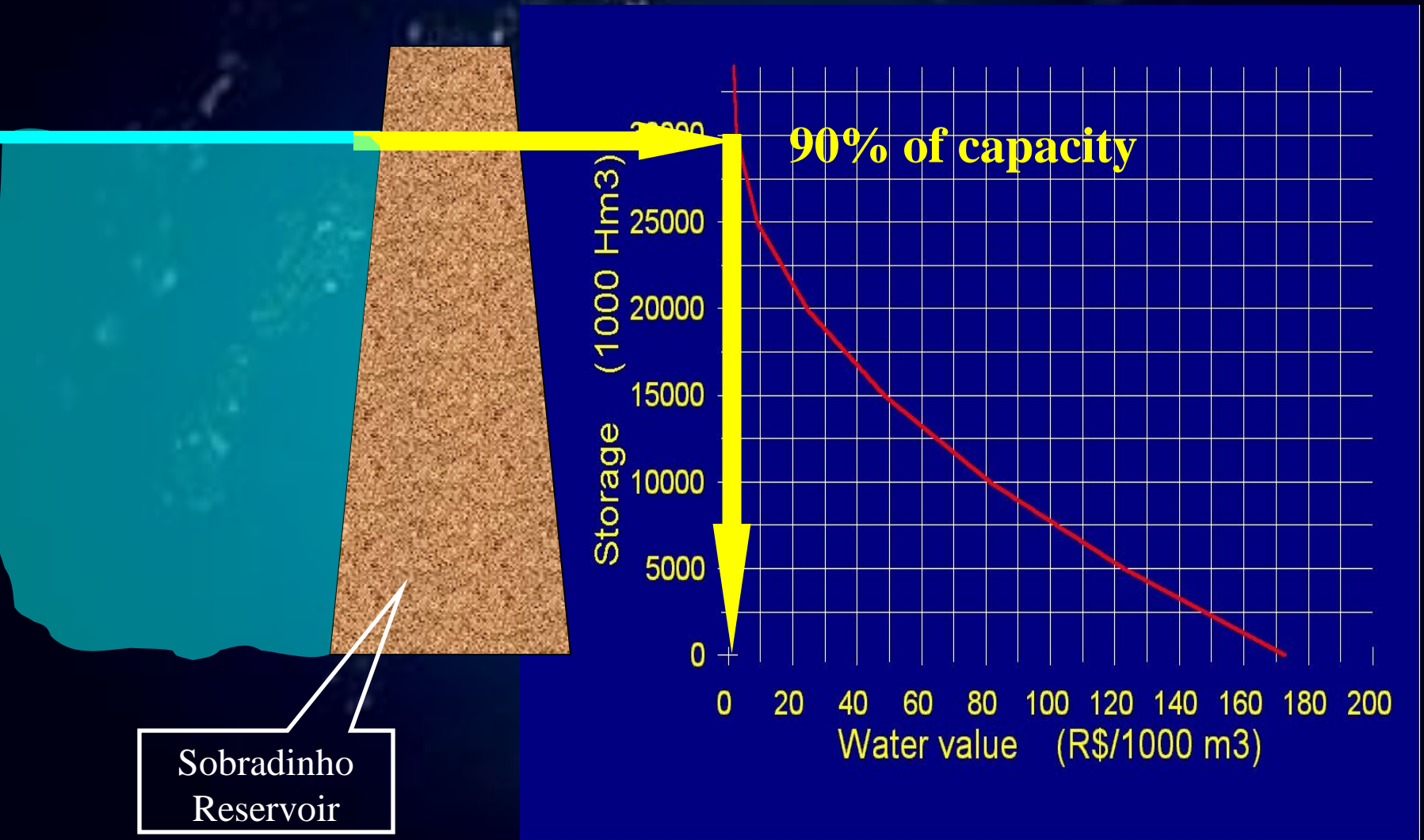
“I will sustain a hunger strike until Government cancels the Project”  
(Bishop Dom Cappio)



- **No Interbasin Diversion Project**
- Build individual water tanks
- Store rain falling on the roofs

**Water for survival**

# Opportunity cost of water in the Sobradinho Reservoir



$Q_{\text{mean}}$  São Francisco River = 2600 m<sup>3</sup> /s

$26 \text{ m}^3 / \text{s} \leq Q_{\text{diversion}} \leq 127 \text{ m}^3 / \text{s}$   
 $1\% \text{ of } Q_{\text{mean}} \leq Q_{\text{diversion}} \leq 5\% \text{ of } Q_{\text{mean}}$

600 Km of channels



However, in developing countries many Government construction works are oversized and don't get proper O&M

A PPP would be a better model for the water diversion project, rather than a pure Government initiative

A private company would design the hydraulic conveyance structure according to commercial contracts for the sale of bulk water, which would ensure the revenues for O&M along many years



We buy treated sewage...

(an Output Based Aid approach)



**Thank you!**

jerson@kelman.com.br