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ANALYSIS OF THE DEMAND RESPONSE IMPACT TO TARIFF FLAGS ECONOMIC SIGNALS IN THE LONG-TERM ELECTRIC-ENERGETIC OPERATION WITH THE INCORPORATION OF RISK AVERSION

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Summary

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- Objective
- What are Tariff Flags?
- Price Elasticity of Demand
- Submarkets ➔ Sectorization of Consumers
- Price Elasticity of Demand – Curves
- Operative Simulations
  - Risk-Averse Approach
- Results
- Conclusions
- Future Works

Objectives

- Analyze the Tariff Flags, a mechanism proposed by ANEEL to foster a demand response program in Brazil
- Present the main effects on the electric-energetic operation of Brazilian National Interconnected System (SIN), considering the recently implemented risk-averse approach

What are Tariff Flags?

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- Proposed on Public Hearing (#120/2010)
- Extinction of economic hour-seasonal signal ➔ correlation between seasons and energy spot price is no longer observed
- **Tariff Flags**: Green, Yellow and Red ➔ short term economic signal that will act as a traffic light and will represent tariff differences to the consumer
- Reflects current system conditions to the consumers
- Help utilities to manage their cash flow more efficiently since tariff readjustment only takes place once a year
- **Target**: all captive consumers of SIN ➔ high and low voltage
- **Test year**: 2014
- **Application year**: 2015

What are Tariff Flags?

- **Green Flag**: indicates low generation costs

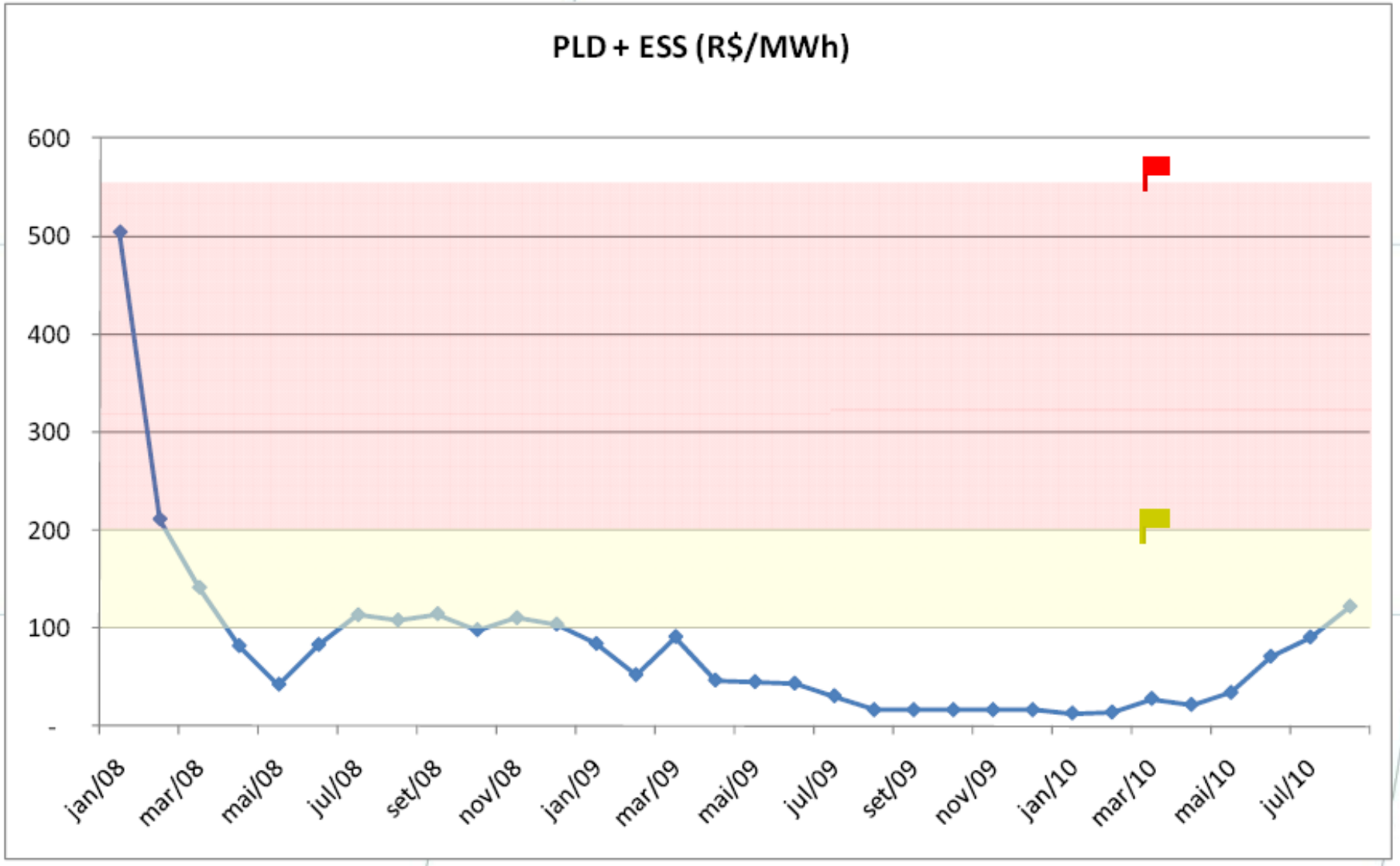
- **Yellow Flag**: indicates a warning sign, which means that the water value reflected in the Short Run Marginal Cost (SRMC) is rising

- **Red Flag**: indicates that the previous situation is getting worse and the balance between supply and demand occurs with higher generation costs

What are Tariff Flags?

Tariff Flags	Original Range {CMO + ESS_{SE}} (R$/MWh)	New Range {CMO} (R$/MWh)	Economic signal (R$/MWh)
Green	< 100	< 200	-
Yellow	≥ 100 e < 200	≥ 200 e < 350	15
Red	≥ 200	≥ 350	30

What are Tariff Flags?



Price Elasticity of Demand (PED)

- To measure the impact of Tariff Flags seen by consumers, the first step is to model the load behavior in relation to price signals (Energy Tariff)

- The responsiveness is measured by the price elasticity of demand, which is different for each economic sector:

Economic Sectors	Price Elasticity of Demand
Industrial	**-0.545**
Commercial	**-0.174**
Residential	**-0.146**

[11] SCHIMDT, C. A. J., LIMA, M.A., Estimações e previsões da demanda por energia elétrica no Brasil, Ministério da Fazenda, Rio de Janeiro, 2002.

Submarkets ➔ Demand Segregation

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- Since elasticity varies according to the economic sector, each submarket is divided into four sectors: residential, commercial, industrial and *others:*

System	% of contribution in each submarket					
	Inelastic Portion			Elastic Portion		
	Free Consumers	Low Income Consumers	Others	Residential	Commercial	Industrial
North	42.13%	10.58%	11.60%	14.89%	12.85%	12.40%
Northeast	19.48%	14.97%	19.26%	19.91%	16.55%	12.75%
South	20.76%	3.27%	14.30%	21.66%	17.27%	23.42%
Southeast/ Central-West	26.23%	3.15%	12.71%	33.20%	16.83%	8.70%

- These percentages were based on Brazilian market data available at [9] and [10]
- The 16 PED curves produced are inputs to the SDDP® Software

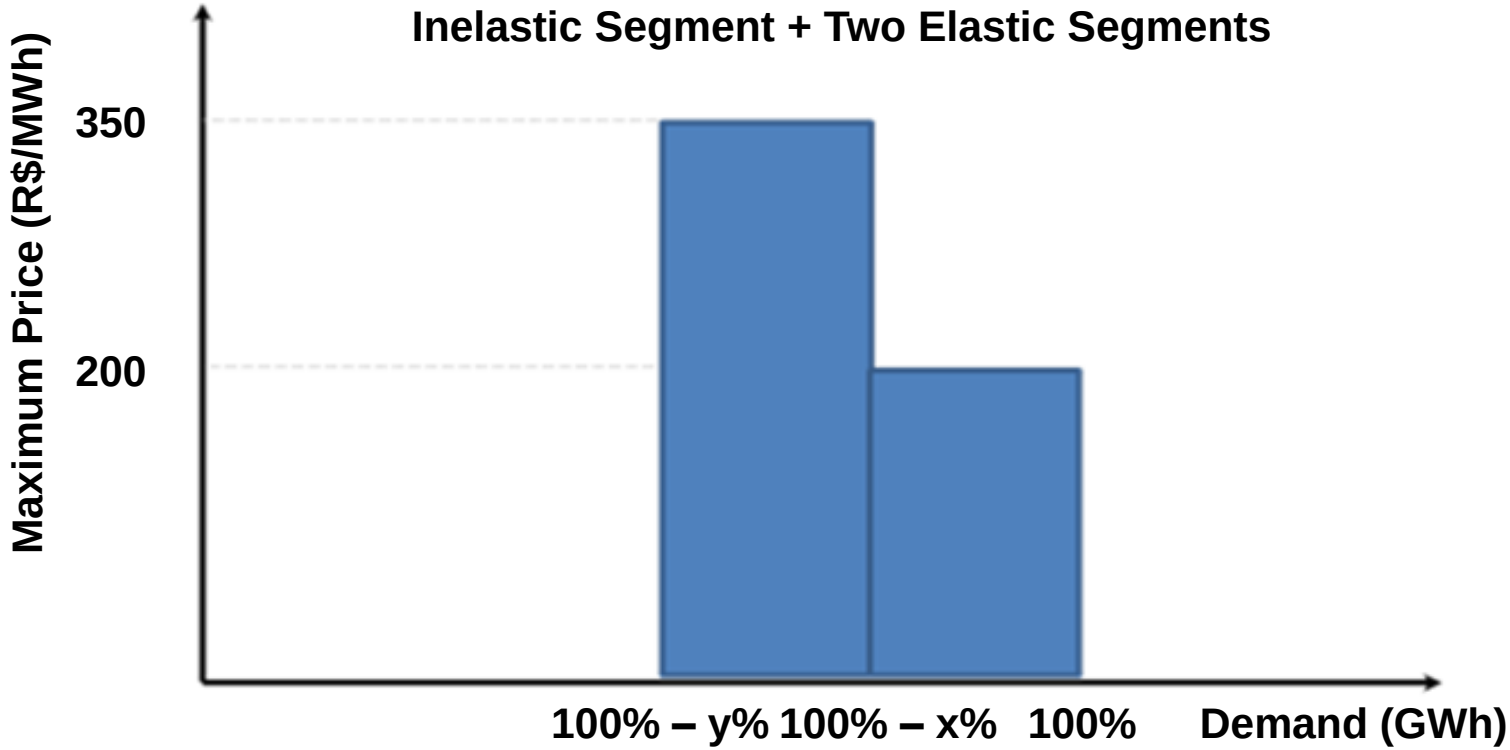
Price Elasticity of Demand – Curves

- The component ***Others*** belongs to the inelastic portion of the demand:

- If the simulation of SIN comprises only inelastic demand, this demand must be met anyway
- Thus, shortfalls are associated to structural problems

Price Elasticity of Demand – Curves

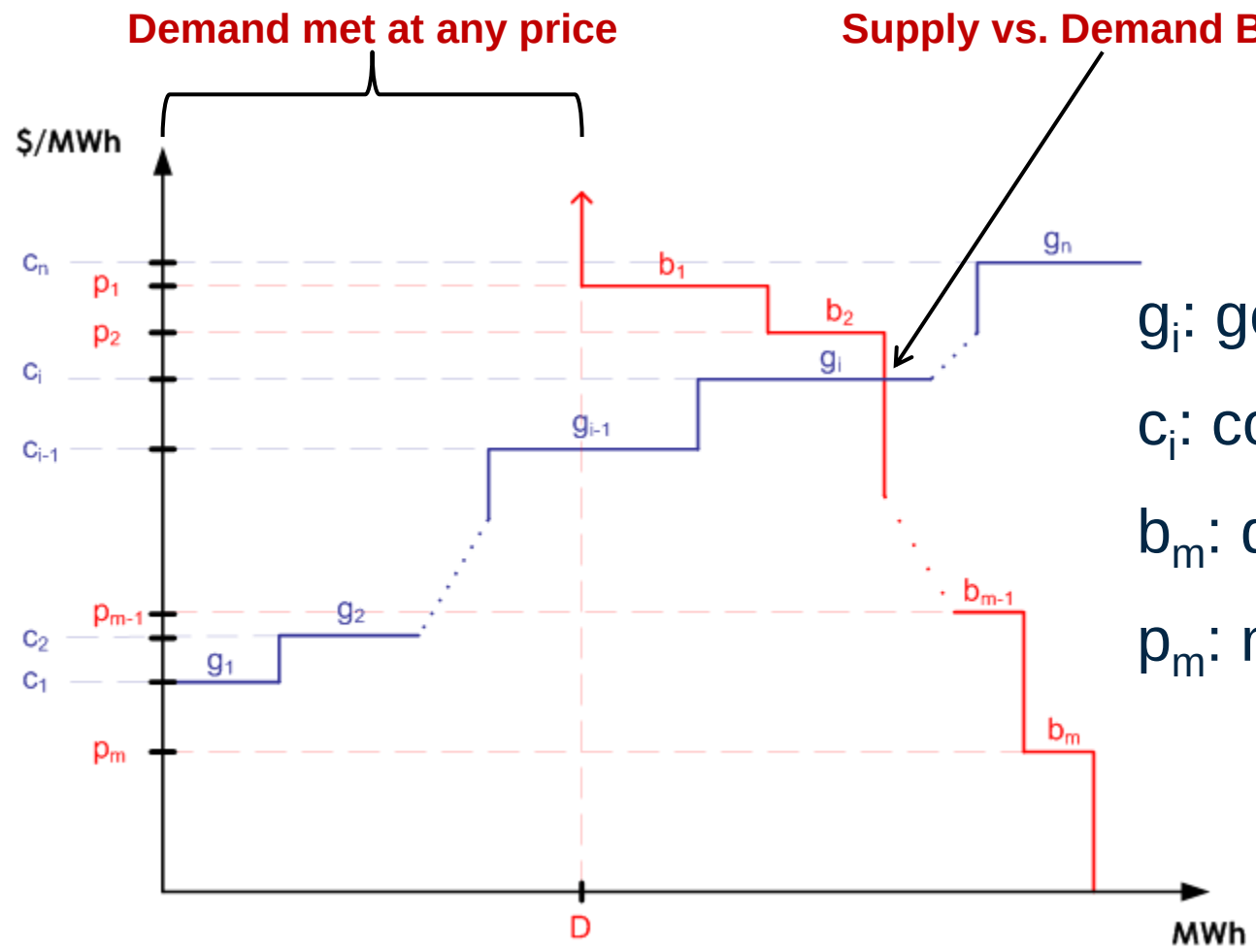
- Residential, commercial and industrial sectors present elasticity curves with three segments - the first being inelastic, the second and third being elastics, as shown below:



Observation: the inelastic segment exists because the load no longer responds to changes in price when the Spot Price is above 350 R$/MWh

Price Elasticity of Demand – Curves

- The optimization process takes into account the demand response to price and seeks the balance between supply and demand



g_i: generation level

c_i: cost of gen. g_i

b_m: demand

p_m: maximum price for b_m

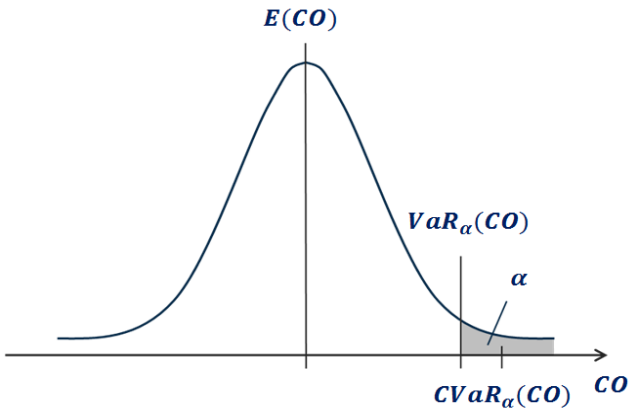
Operative Simulations

- Three simulations were performed based on the Monthly Operation Program (PMO) of December 2013:
  - Case 1 – Demand ➔ Totally Inelastic
  - Case 2 – Demand ➔ Economic Sectors + Original Tariff Flags Range
  - Case 3 – Demand ➔ Economic Sectors + New Tariff Flags Range
- Study Horizon: 2013 – 2017
- Simulations performed on SDDP®

Risk-Averse Approach

- The CNPE nº 03/2013 Resolution determined the insertion of the risk aversion approach into the operation planning model
- The main objective of this methodology is to ensure system's security of supply, through the optimal policy and no longer by supplementary actions
- Short-term some consequences:
  - PLD (SRMC) expected value rises;
  - ESS_{SE} dramatically reduced or non existent.
- The objective function has been changed in order to minimize a convex combination of the system operating expected cost and its *CVaR (Conditional Value at Risk),* as follows:

$$\boldsymbol{Objective\ Function \Rightarrow Min\ (1-\lambda) * E(OC) + \lambda * CVaR_{\alpha}(OC)}$$

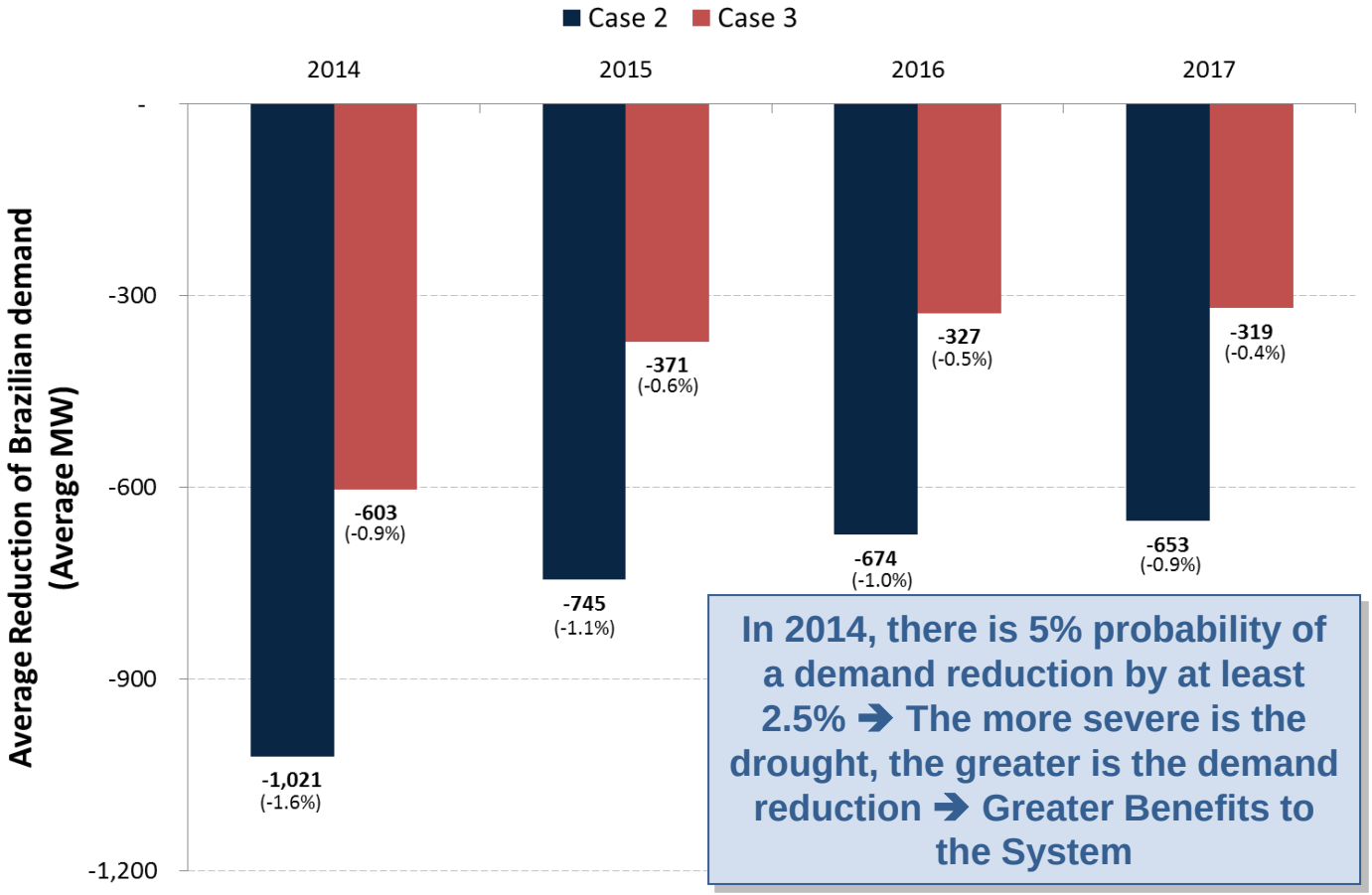


Results

- Since Tariff Flags will act as traffic lights, reflecting directly the generation cost through increments on the Energy Tariff, a demand response is expected and could have impacts in the total system operating cost

- In order to measure the impacts, simulations of the system operation were performed, considering the demand response to the economic signals of Tariff Flags

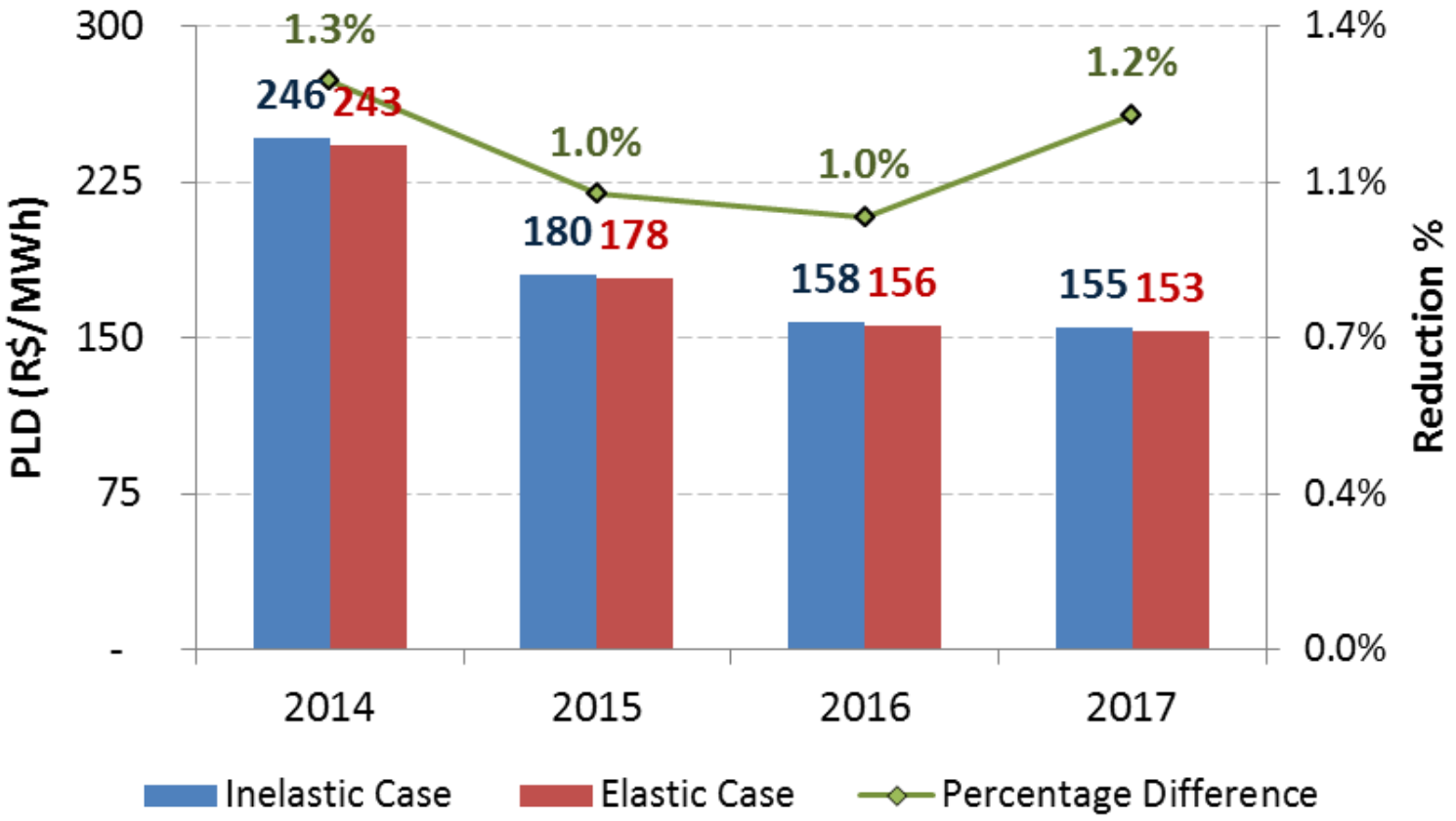
Total Demand Reduction



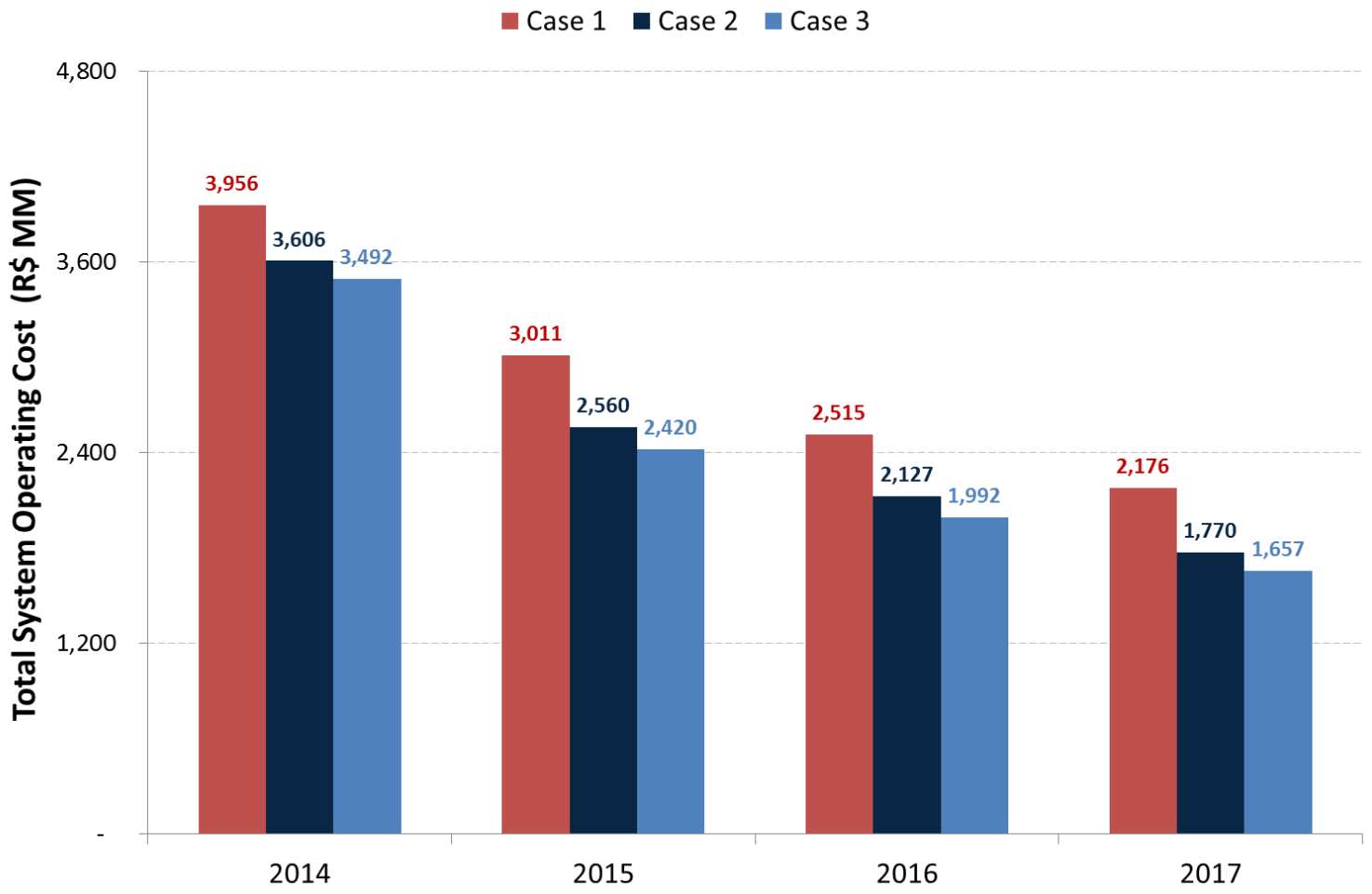
- Case 2: average reduction in the total demand ranges between 1,000 and 650 Average MW, which is equivalent to 1.6% and 0.9%
- Case 3: average reduction in the total demand ranges between 600 and 320 Average MW, which is equivalent to 0.9% and 0.4%

PLD Change of Southeast/Central-West

- Average Energy Spot Price (Case 3):



Total System Operating Cost



- Between 2014 and 2017 there is an expected reduction of R$ 2 billions in system operating costs (Case 3)

Occurrence Probability of Each Tariff Flag

Yellow Flag	2014	2015	2016	2017
Case 1	0.25	0.27	0.24	0.22
Case 2	0.27	0.24	0.23	0.22
Case 3	0.27	0.19	0.17	0.22
Red Flag	**2014**	**2015**	**2016**	**2017**
Case 1	0.52	0.33	0.29	0.08
Case 2	0.32	0.28	0.25	0.08
Case 3	0.24	0.14	0.11	0.08

- **Red Flag** always **LESS** triggered in Case 3
- Decrease in the occurrence of high PLDs ➔ increased occurrence of intermediate PLDs ➔ **Yellow Flag**

Conclusions

- Simulation results have shown that tariff flag mechanism implementation and its expected demand response have positive impacts to the system
- Average increase of 0.1% in the Southeast/Central-West reservoir level, 0.6% in the South, 0.04% in the Northeast and 0.7% in the North
- Reduced thermal dispatch and system operating costs
- All submarkets have lower average PLDs in the elastic case
- **Summary:** when demand responds to price, the average spot prices are lower and the probability of triggering the red flag is always lower

Future Works

- Development on elasticity indices is needed ➔ ideally, there should be adopted different elasticity indices for each submarket or even for each concession area of distribution companies
- The application of the Tariff Flag mechanism may create another source of uncertainty in energy contracting by utilities, therefore, further studies should be carried out to analyze in details the impacts for each specific company
- There are scenarios that presents a more pronounced demand reduction, reaching about 2.5% ➔ This methodology can be used to analyze the demand reduction for each specific utility of the Brazilian system

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Thank you!

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