

# MODELLING THE RESPONSE OF DEMAND SEGMENTS FOR NATURAL GAS IN BRAZIL AND THE PERSPECTIVES FOR CARBON ABATEMENTS

Presentation of Project 24 (with the participation of Project 8)

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Research Centre  
for Gas Innovation

cleaner energy for a sustainable future

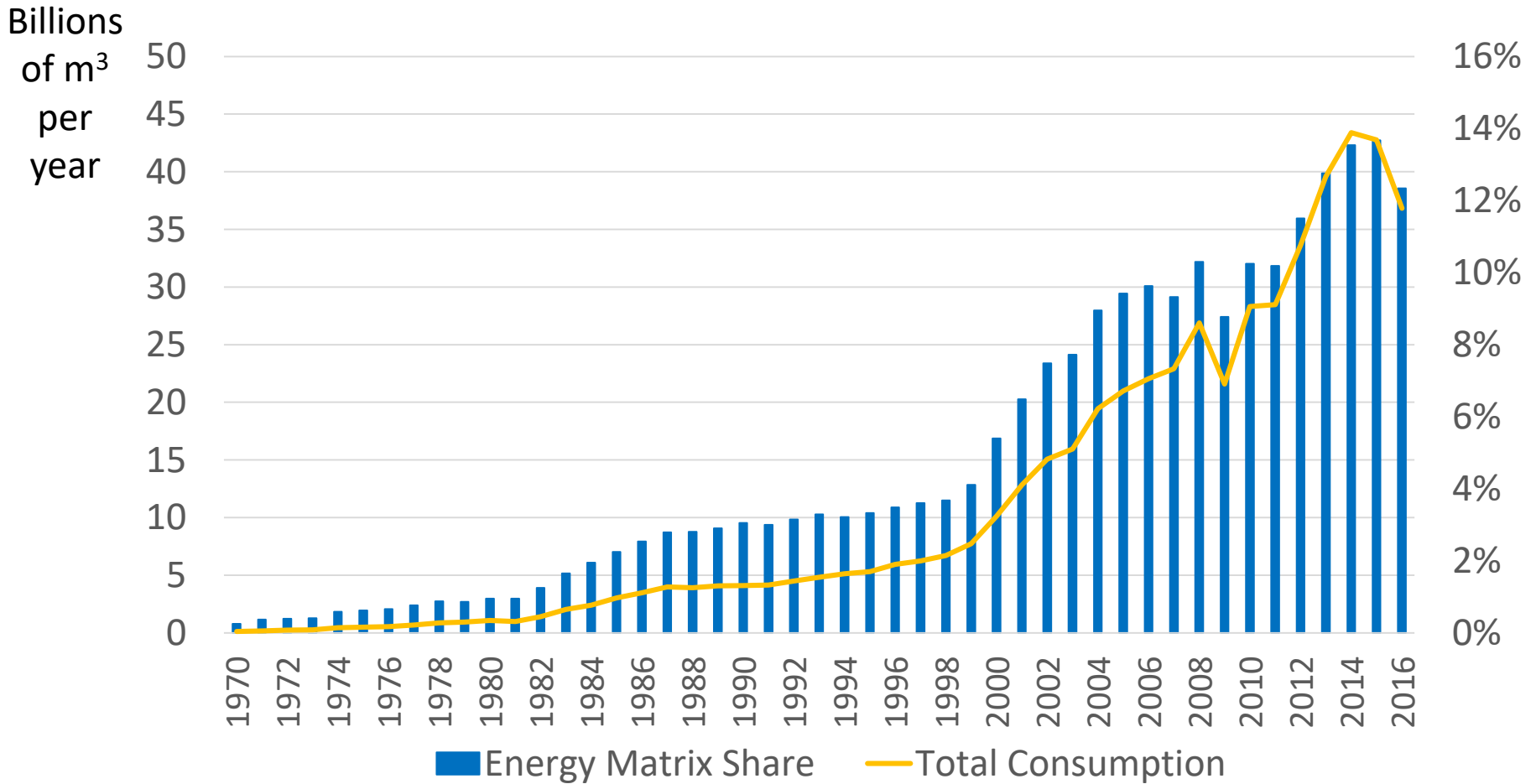
V Internal Workshop - RCGI  
University of Sao Paulo,  
21 – 22 August 2018



# Summary

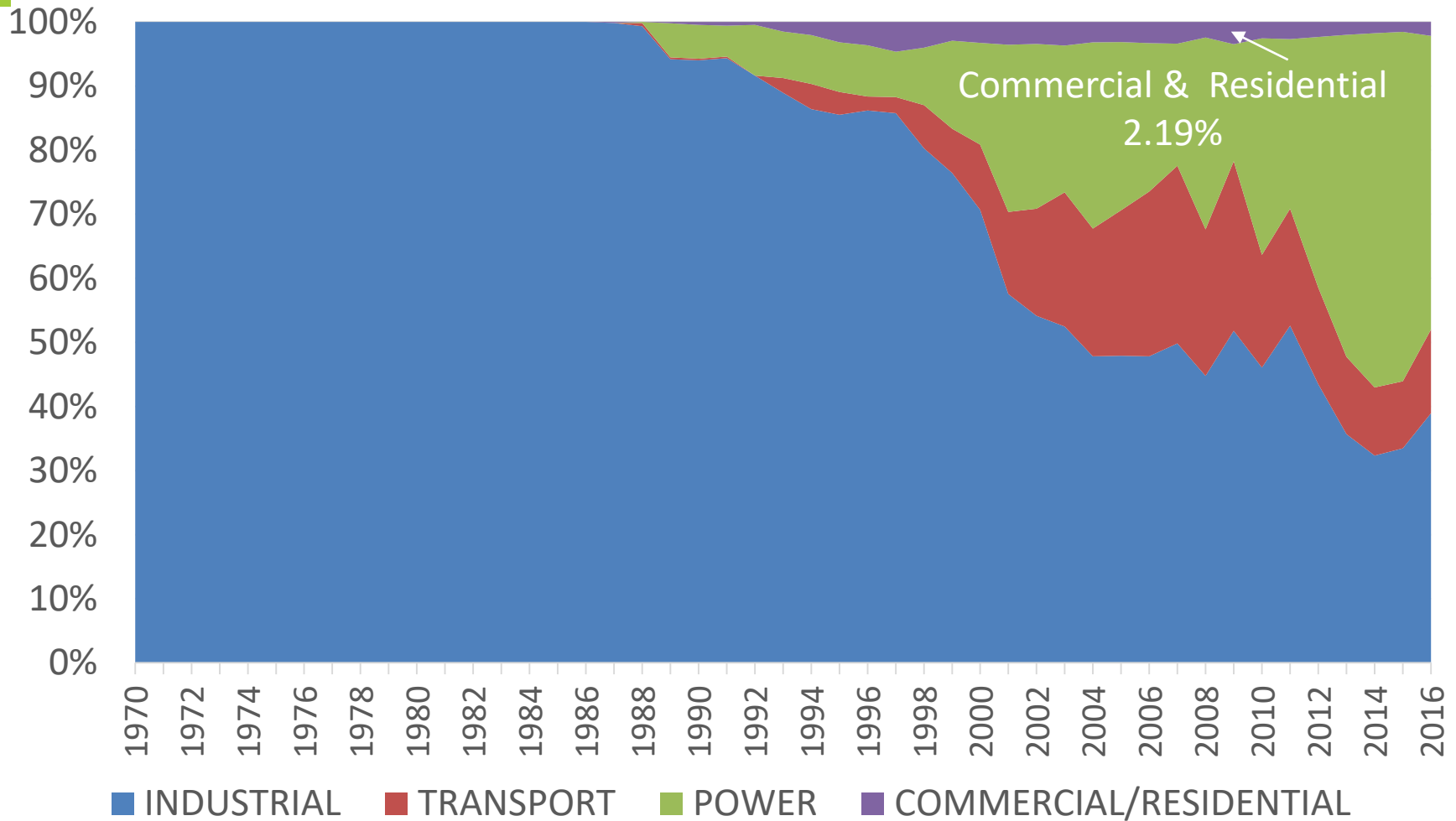
- ✓ Context of residential NG demand in Brazil
- ✓ Brief literature review on residential NG
- ✓ Challenges: selecting variables and gathering data

# Total NG consumption and share in the Brazilian energy matrix



# Consumption of NG by sector\* (1970-2016)

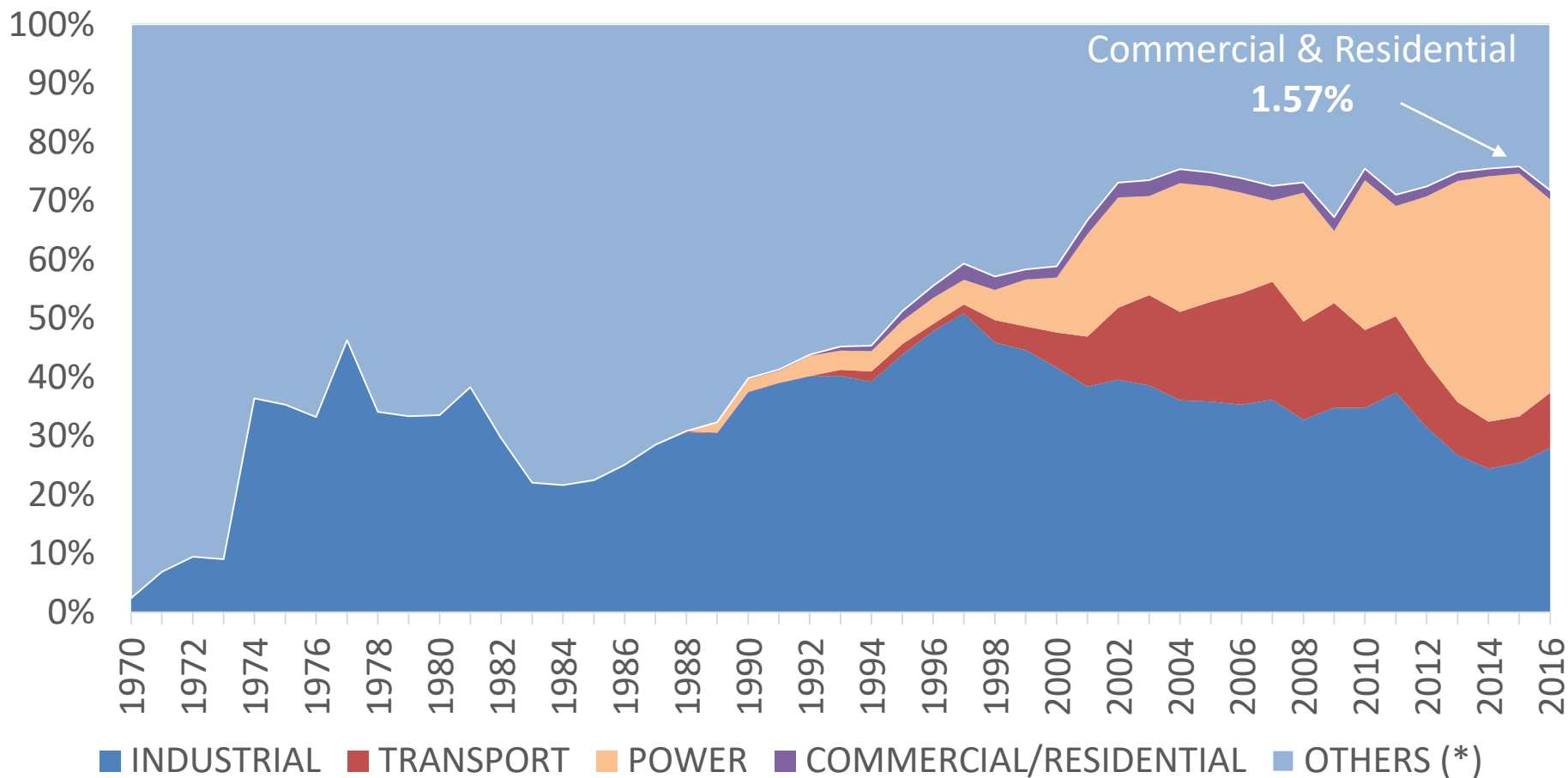
(\* ) does not include consumption in the production of petroleum derivatives...



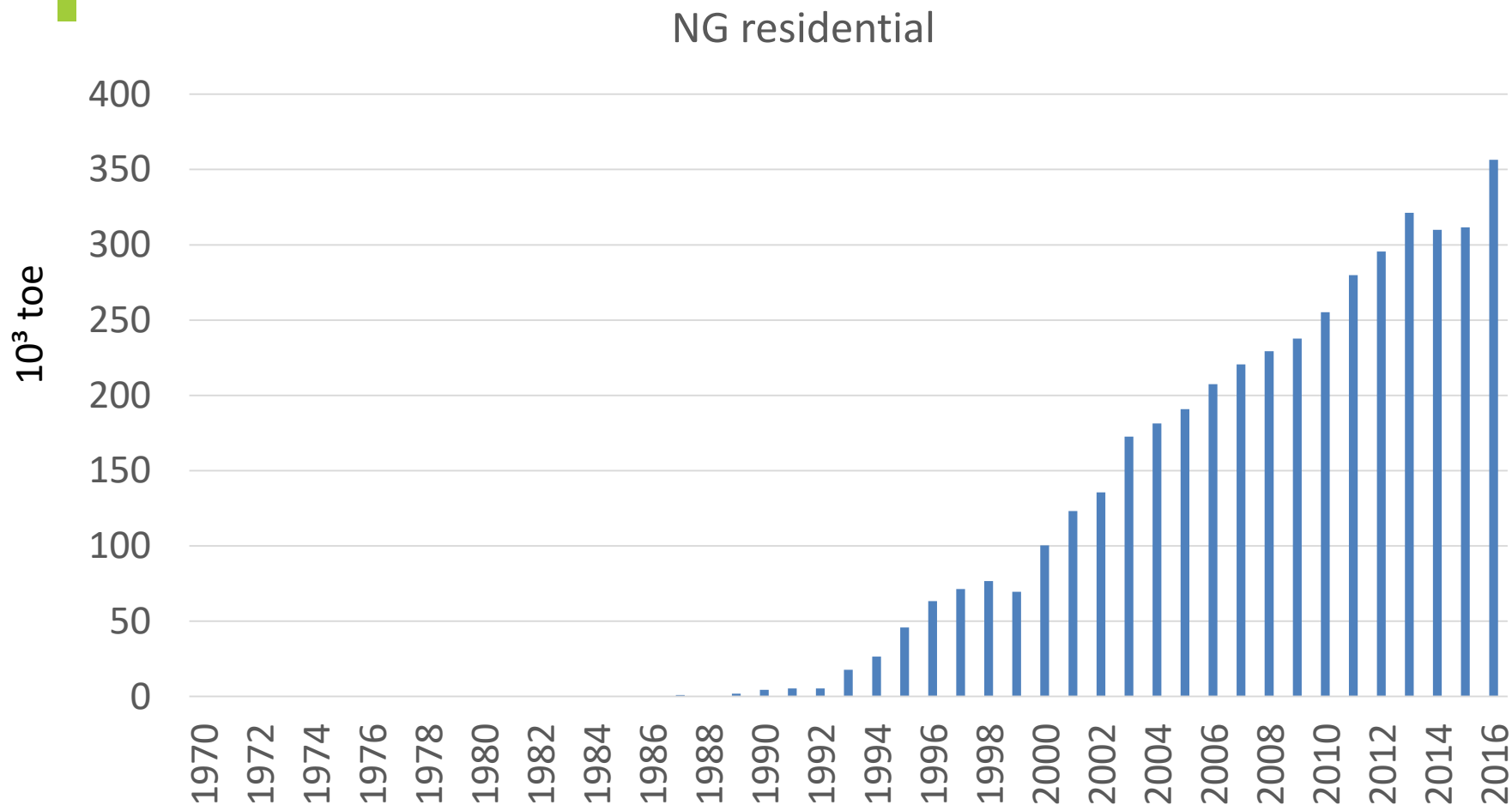
# Consumption of NG by sector (1970-2016)

(In 2016 there are still too much “others”\*)

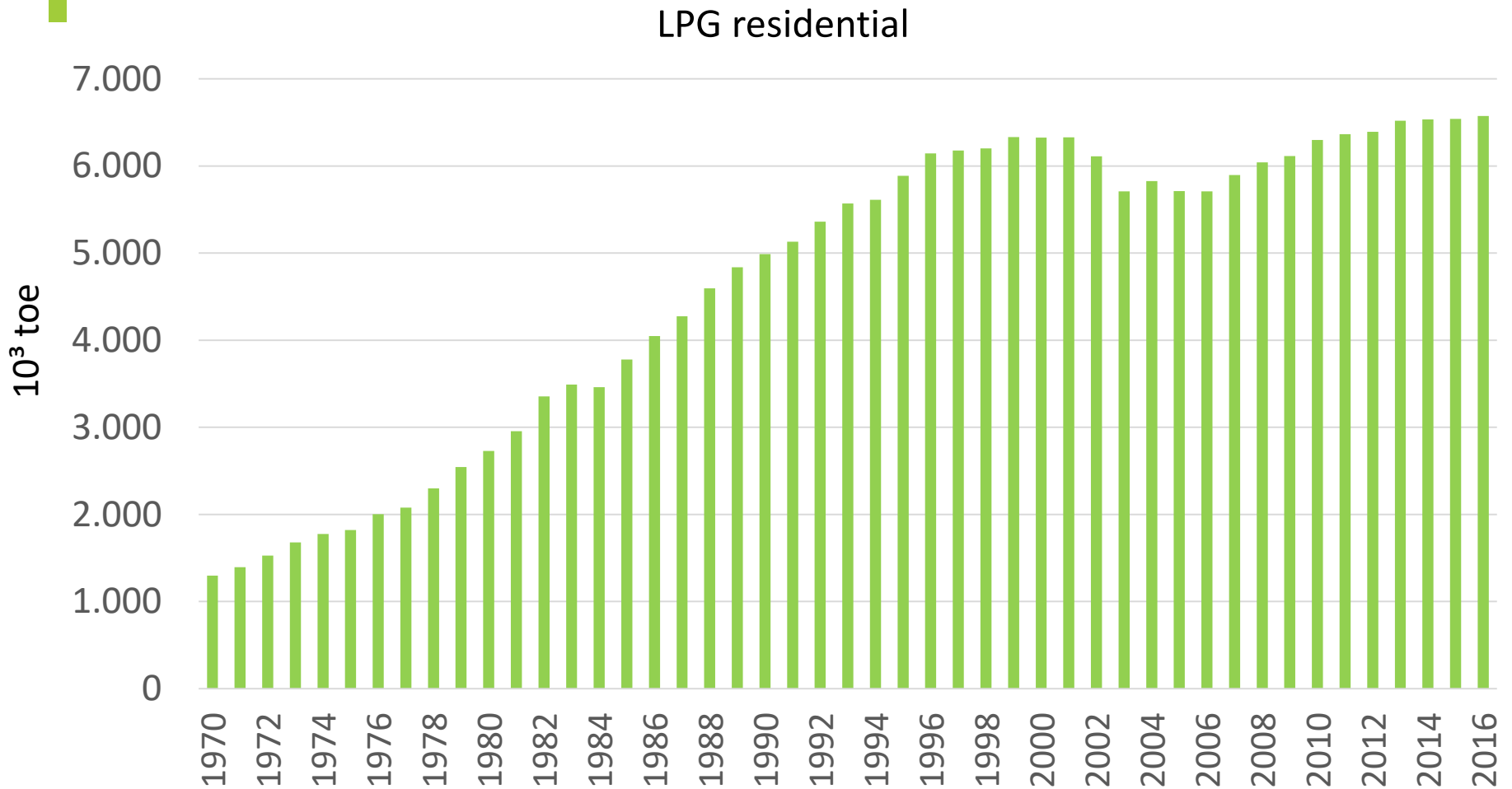
(\*) Includes consumption in the production of petroleum derivatives, non-energy final consumption and the energy sector's own consumption, except electric generation



# Residential NG consumption – 10<sup>3</sup> toe



# Residential consumption of LPG – 10<sup>3</sup> toe



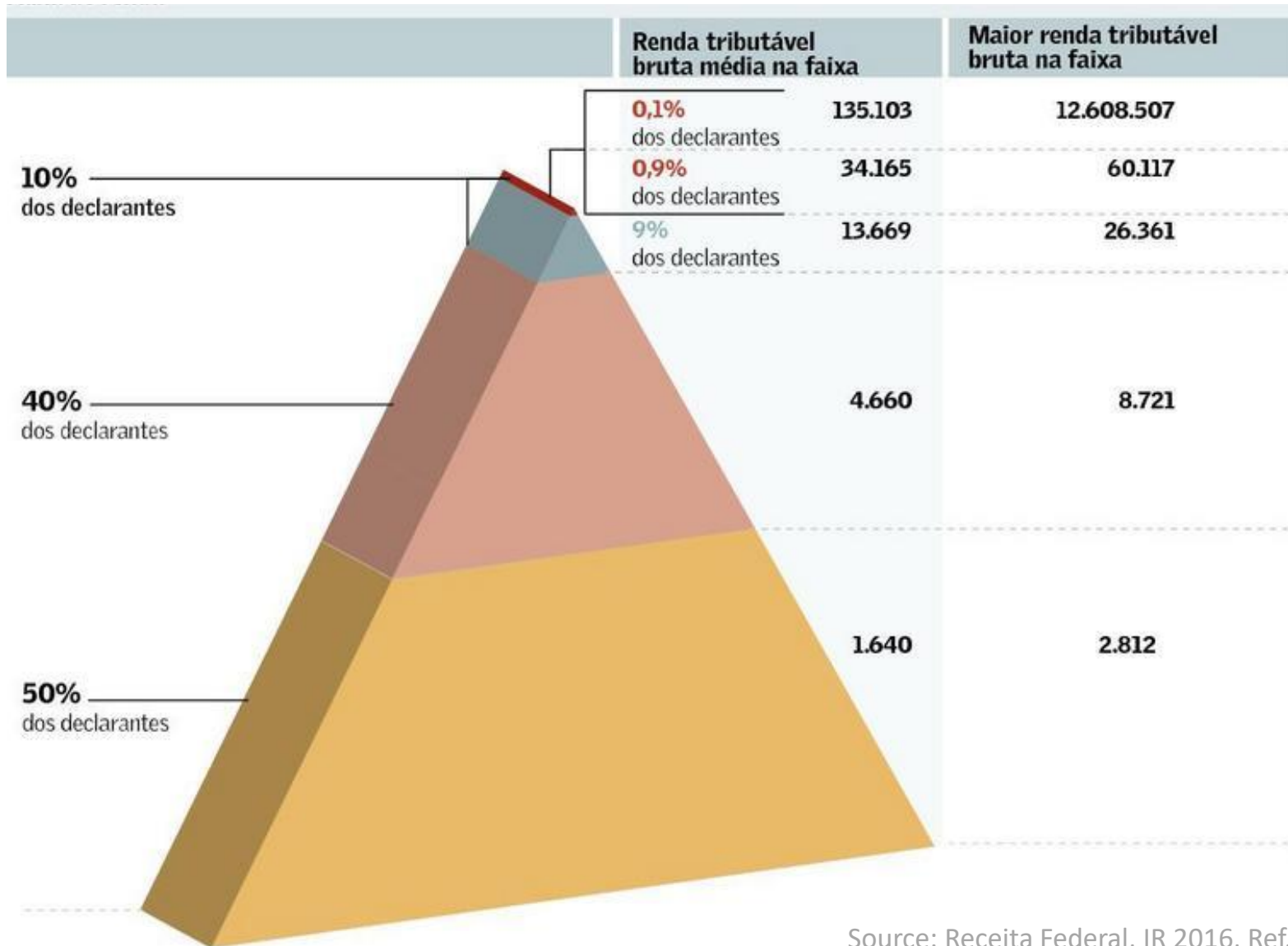
## Which variables may affect the NG residential demand in Brazil?

- ✓ price of natural gas ( $Price_t$ ) ?
- ✓ real gross domestic product ( $GDP_t$ ) ?
- ✓ per capita income ( $GDP_t/Pop_t$ ) ?
- ✓ net increase in population ( $Pop_t$ ) ?
- ✓ per capita income in tiers (A, B, C)?
- ✓ price of electricity ( $Ele_t$ ) ?
- ✓ price of charcoal ( $Cha_t$ ) ?
- ✓ price of LPG ( $LPG_t$ ) ?
- ✓ price of conversion ( $Conv_t$ ) ?

- ✓ weather and/or time of the year?
- ✓ degrees away from mean temperature?
- ✓ dummy for access to pipeline?
- ✓ dummy for access to trad. biomass?
- ✓ time spent on collecting trad. biomass?
- ✓ neighbourhood density/ verticaliz.?
- ✓ # of people in dwelling?
- ✓ dummy for microwave?
- ✓ dummy for wood burning stove?

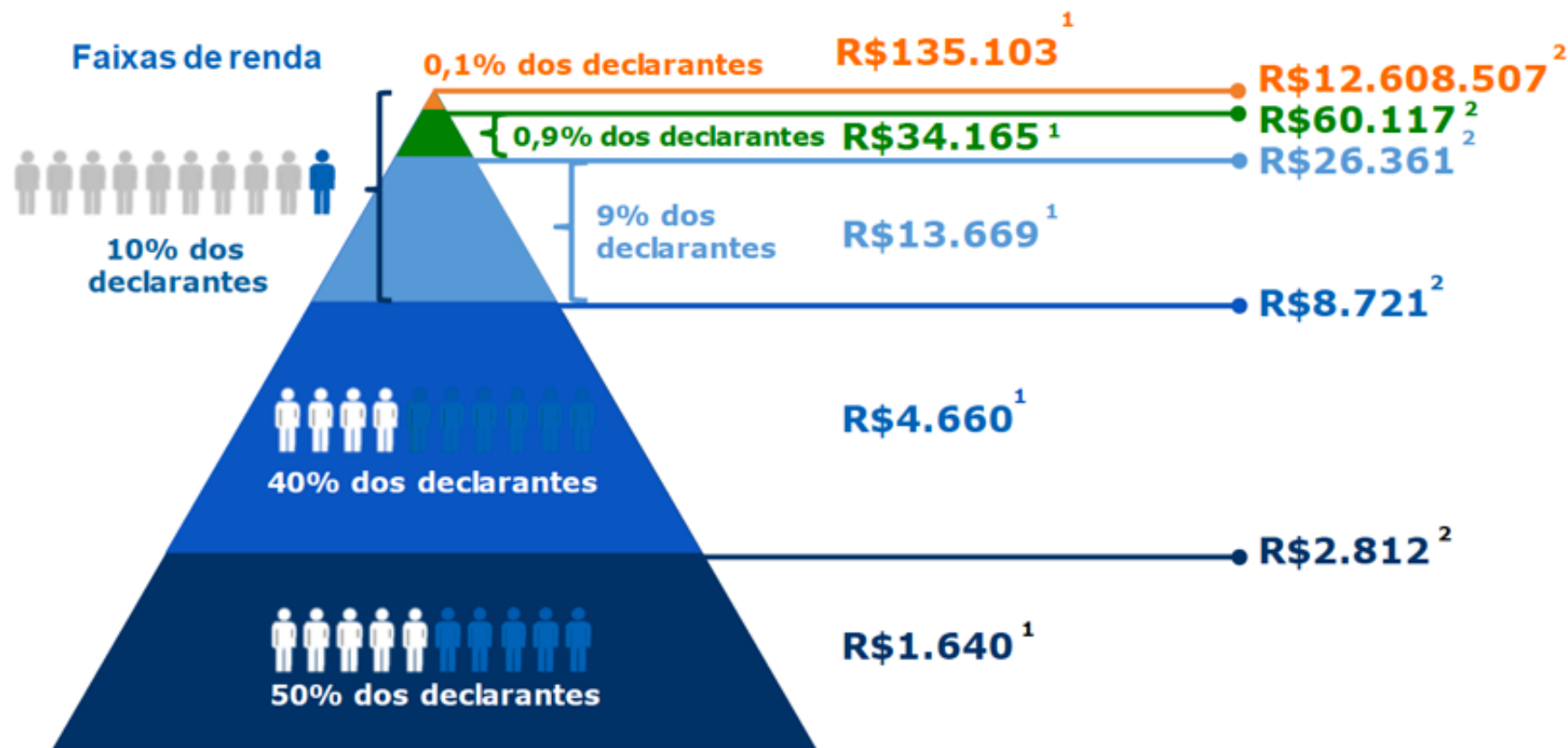


# Monthly tax brackets for taxpayers in Brazil - 2016



Source: Receita Federal, IR 2016, Ref. 2015.

## 50% dos declarantes ganham até 3,9 Salários Mínimos, que corresponde a 73,3% da População Economicamente Ativa

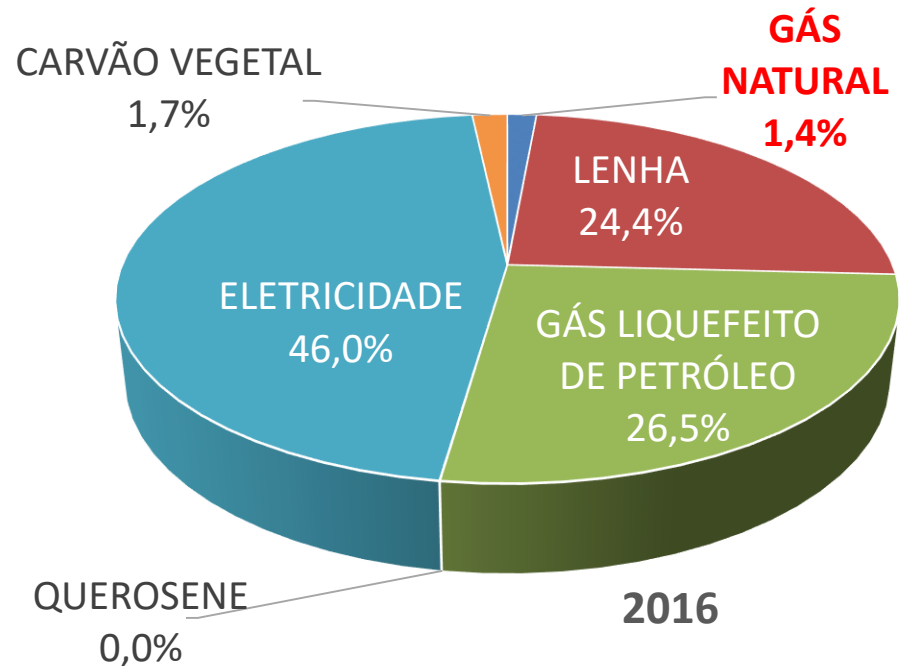
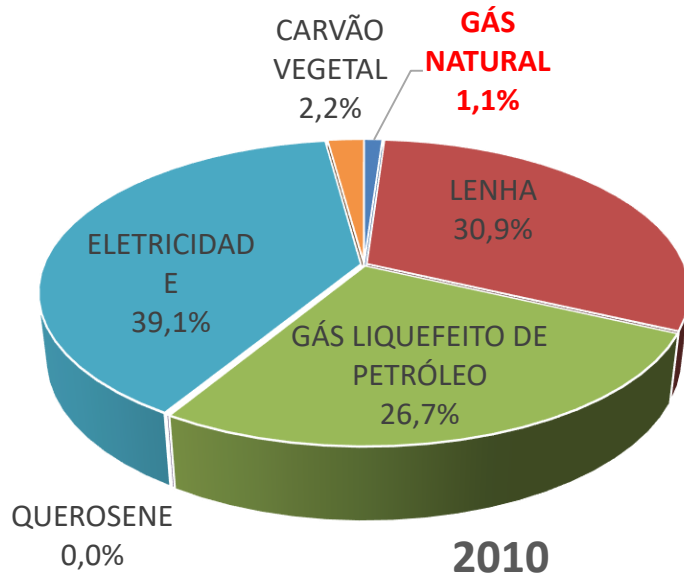
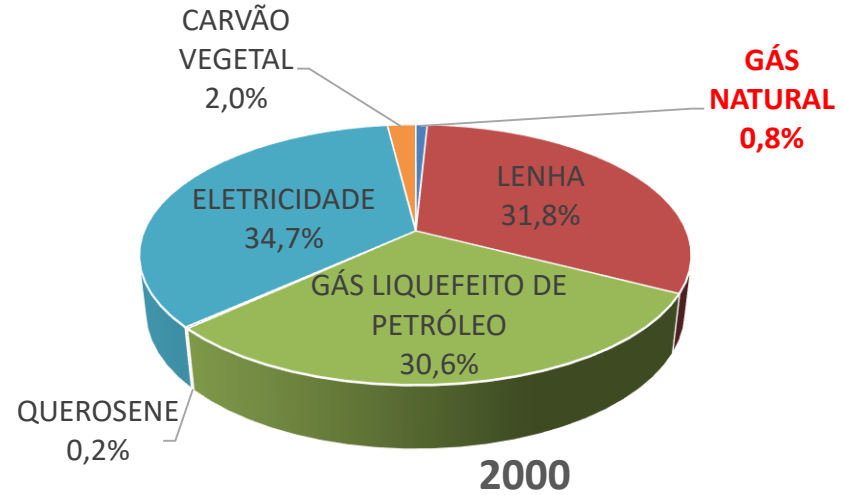
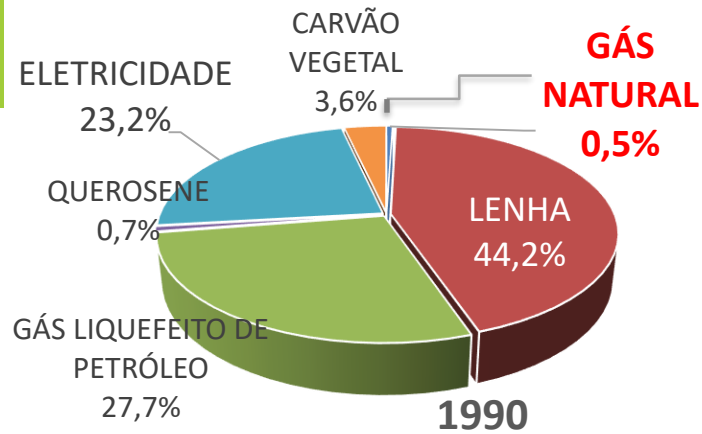


<sup>1</sup> Renda Tributável Bruta média por declarante da faixa

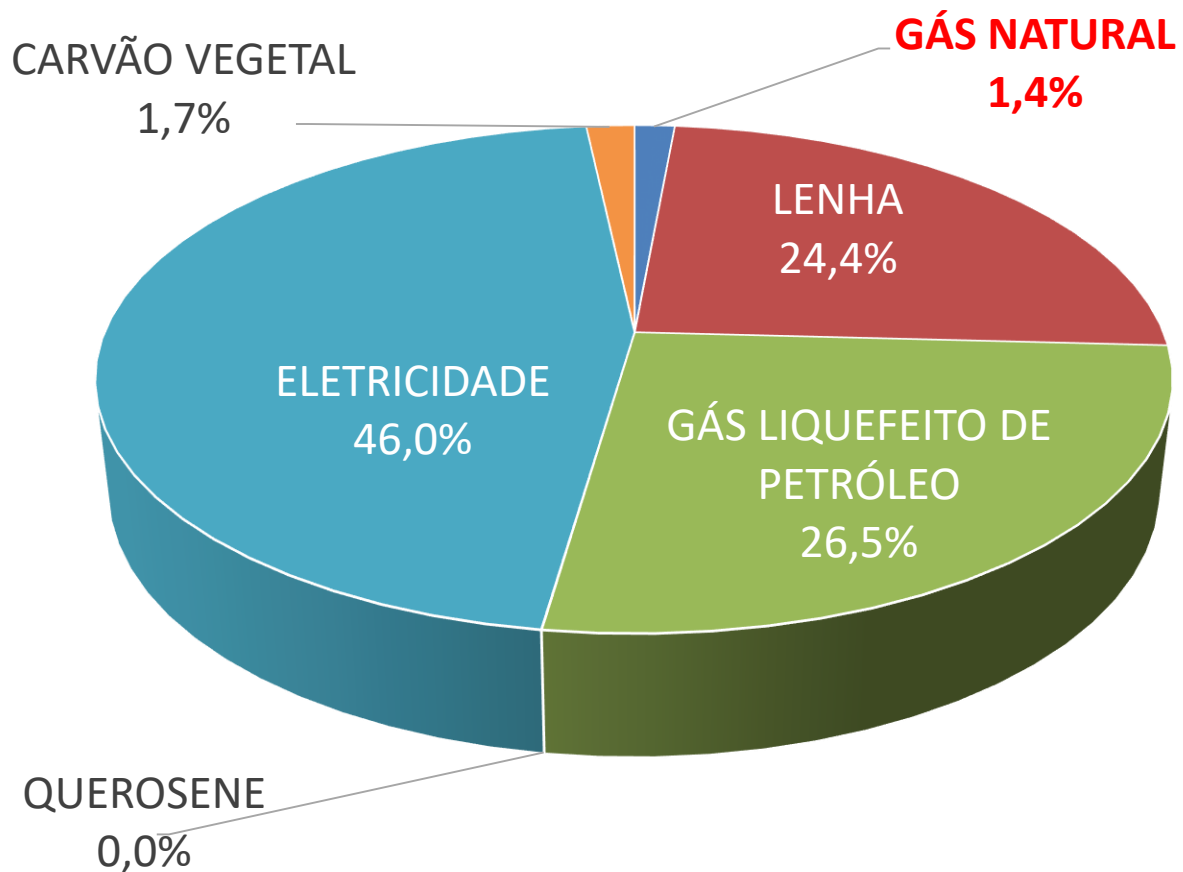
<sup>2</sup> Renda do contribuinte com maior Renda Tributável Bruta da faixa

Source: Receita Federal, 2016.

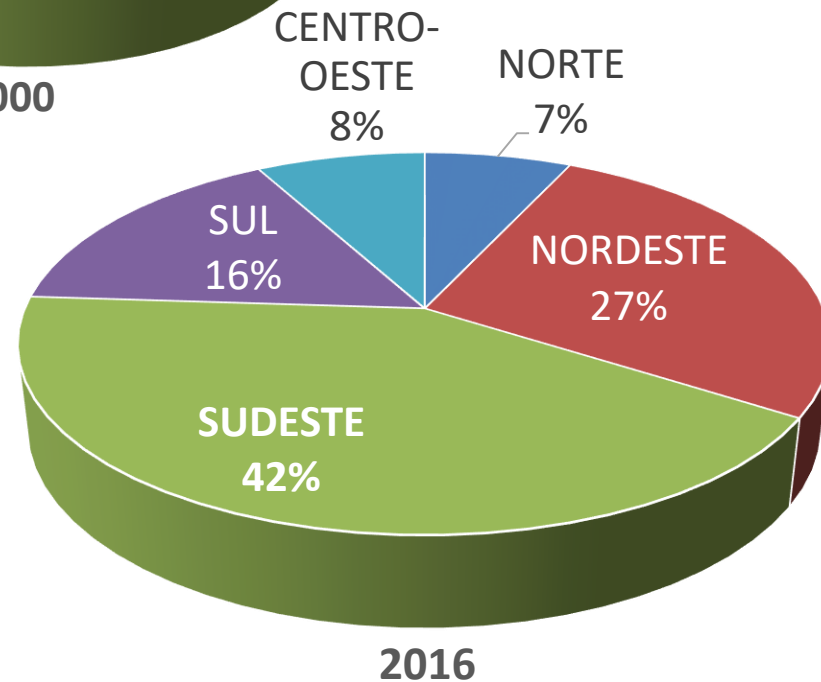
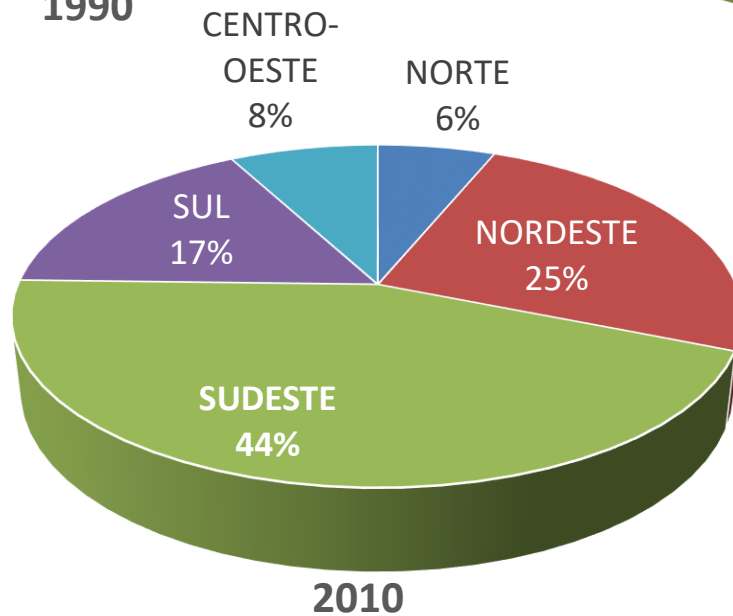
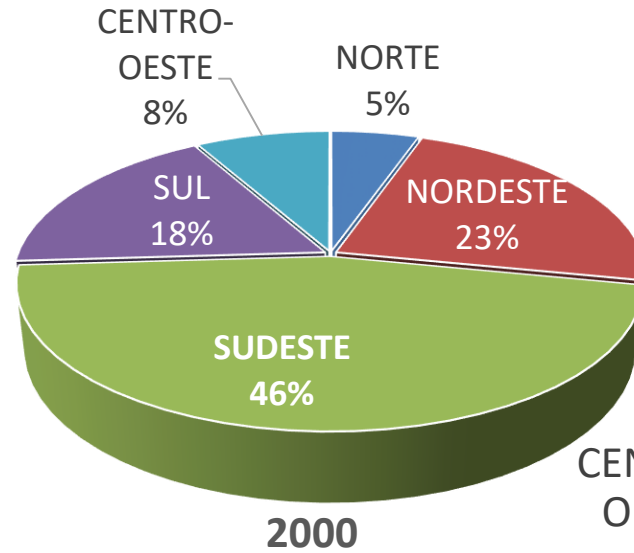
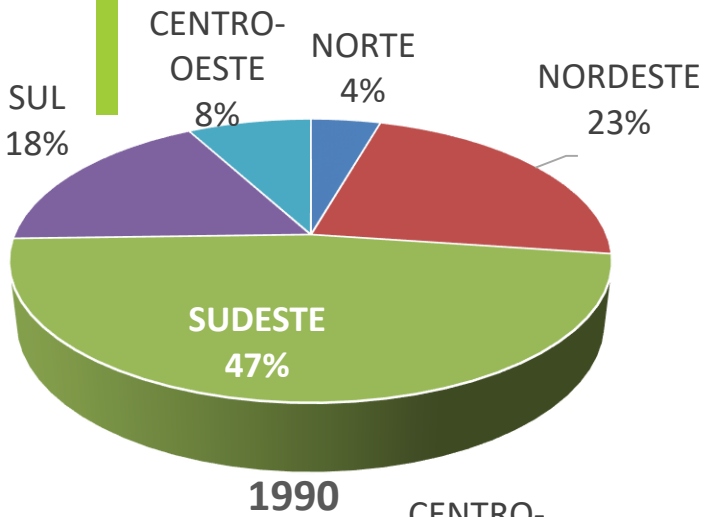
# Evolução do Consumo Energético Residencial 1990-2016



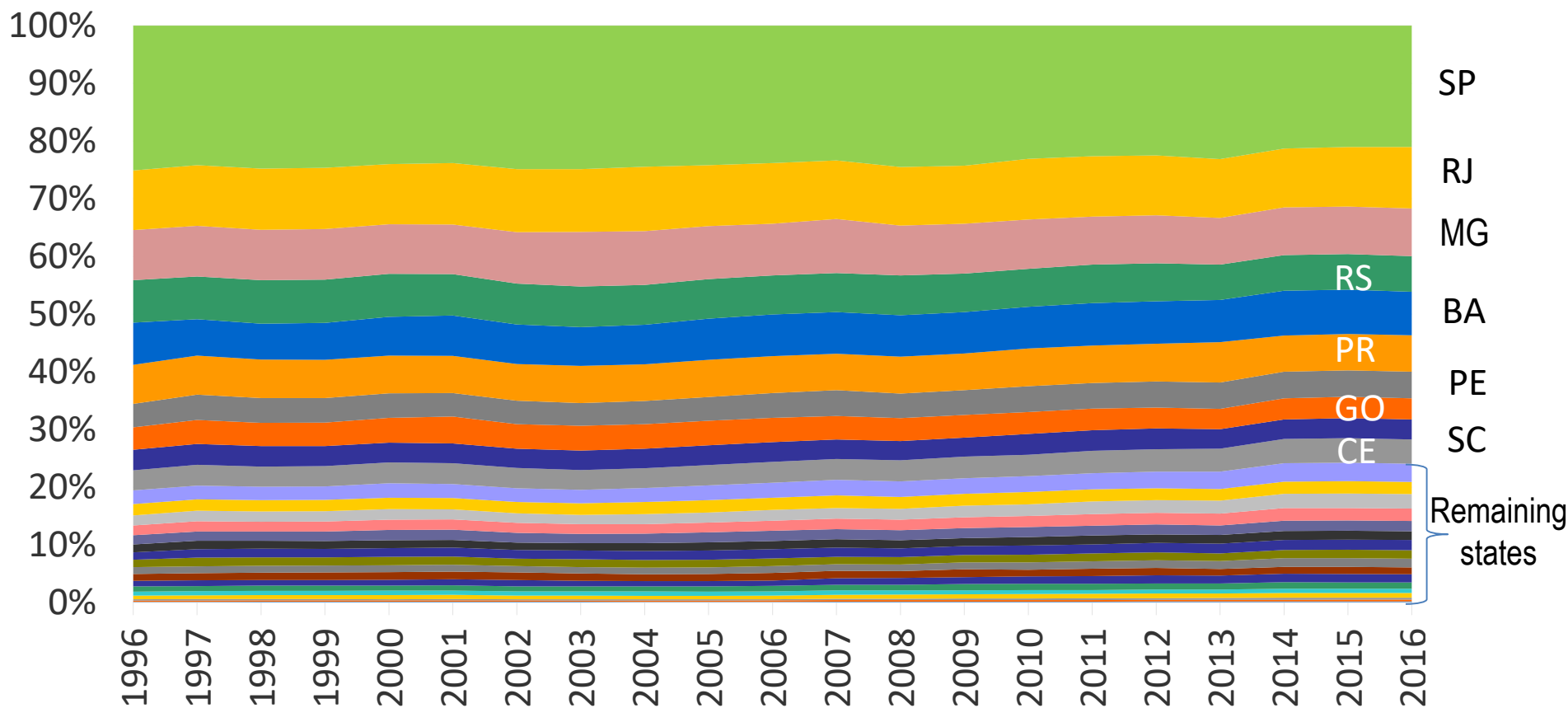
# Residential Energy Demand in 2016



# Residential Demand of LPG by Region



# Residential demand of LPG by state





# Summary

- ✓ Context of residential NG demand in Brazil

- ✓ Brief literature review on residential NG

- ✓ Challenges: selecting variables and gathering data

# Residential natural gas demand elasticities in OECD countries: An ARDL Bounds Testing Approach

(Berstein & Medlener – FCN Working Paper 15 (2011))

- ✓ Analyses residential natural gas demand in 12 OECD countries from 1980 and 2008
- ✓ Estimates long-run demand price and income elasticities
- ✓ Applies Auto-regressive Distributed Lag (ARDL) model

Model: 
$$g_t = \beta_0 + \beta_1 t + \beta_2 y_t + \beta_3 p_t + \beta_4 hdd_t + \varepsilon_t$$

Where:  $g_t =$  residential natural gas consumption per capita

$y_t =$  residential net disposable *income*

$p_t =$  real natural gas *price*

$hdd_t =$  variable which controls *temperature* (heating degree days – hdd)

## Results:

- On average across all the countries, the long run elasticities with regard to price and income are found to be **-0.51** and **0.94** respectively and **1.35** for the weather
- The model also indicates a **short-run income elasticity of 0.45**, a **short-run price elasticity of -0.24**, and a **short-run weather elasticity of 0.72**



# The determinants of residential gas demand in Ireland

Jason Harold, Seán Lyons, John Cullinan - Energy Economics 51 (2015)

- ✓ Examines the determinant of residential gas demand in Ireland
- ✓ Applies micro-econometric analysis for the daily gas consumption in panel data
- ✓ Sample of 1181 households over 539 days

Model:  $G_{it} = \alpha + \beta X_i + \gamma Y_i + \delta W_t + \tau D_{it} + \pi Z_i + \epsilon_{it}$

Where:  $G_{it}$  = daily natural gas demand of households

$X_{it}$  = vector of **socio-economic characteristic** of chief economic supporter (CES)

$Y_i$  = matrix of **household level characteristic**, includes **number** of members

$W_t$  = **weather** variables

$D_{it}$  = **time and season** dummies

$Z_i$  = matrix of **dwelling characteristics**

Results → **Weather** and **socio-economic characteristic** of the households were the significant factors in explaining residential natural gas demand

# Modelling and forecasting the demand for natural gas in Pakistan

Khan. Renewable and Sustainable Energy Review, 49 (2015).

- ✓ Examines both short and long-term dynamics of natural gas consumption from 1978 -2011, through econometric (Ordinary Least Square – OSL) model.

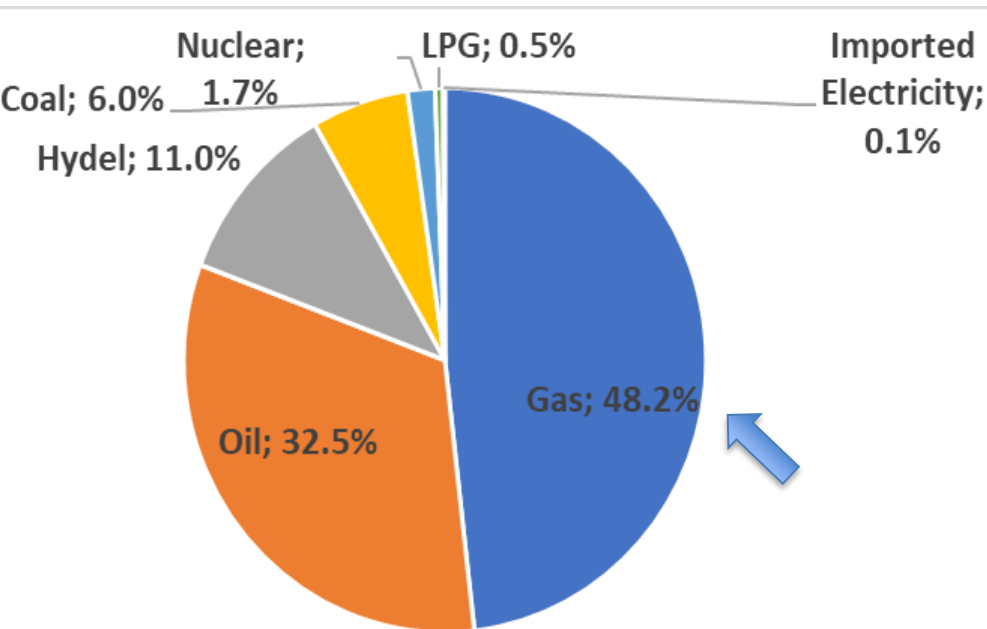


Fig.1: Primary energy supply by source, 2013

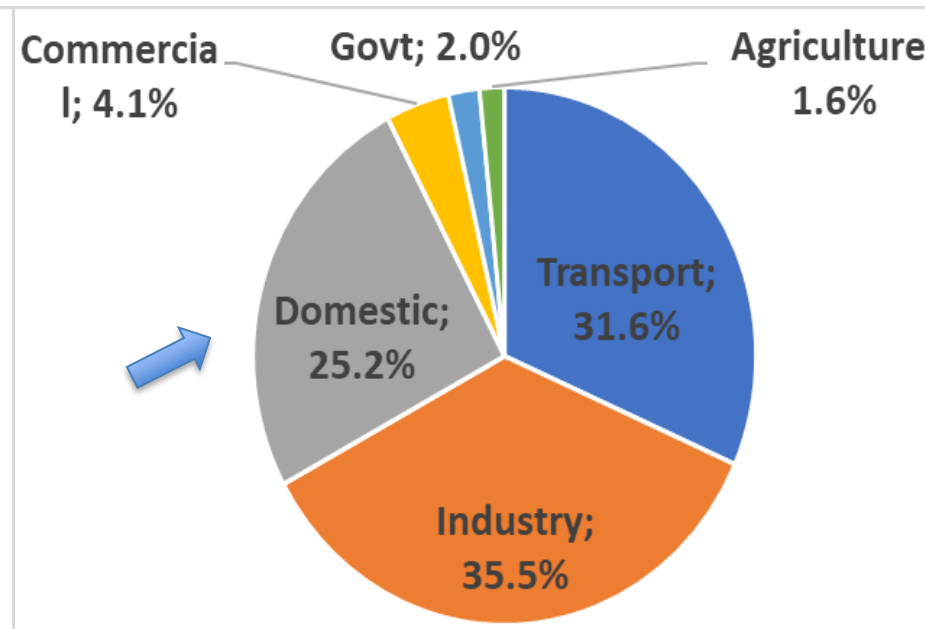
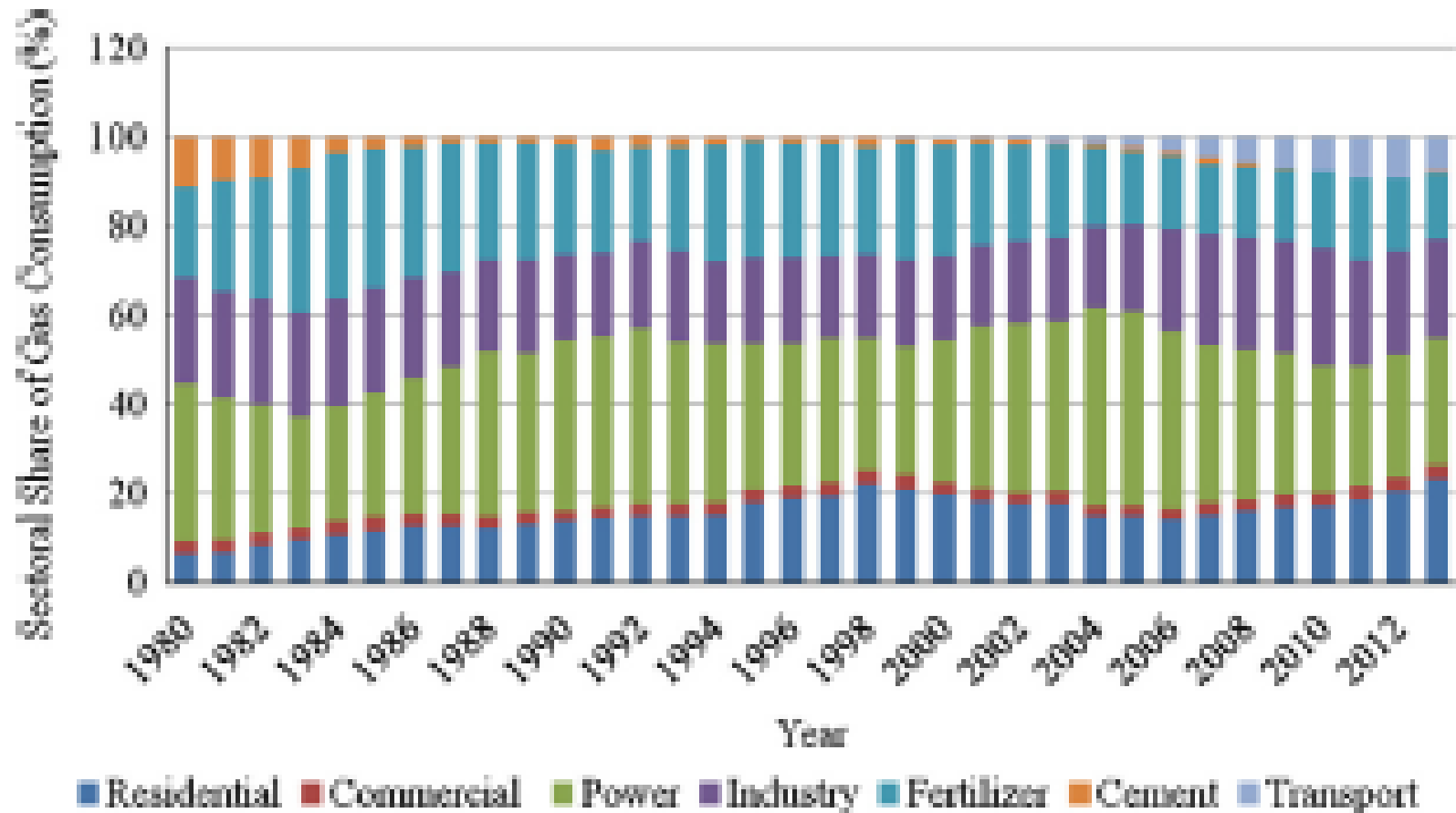


Fig.2: Primary energy demand by sector, 2013

# Modelling and forecasting the demand for natural gas in Pakistan

Khan– Renewable and Sustainable Energy Review 49 (2015)



**Fig. 6.** Sectoral shares of natural gas consumption during 1980–2013 (in %) [4,37].

# Modelling and forecasting the demand for natural gas in Pakistan

(Khan– Renewable and Sustainable Energy Review 49 (2015))

Model:

$$G_{rt}^D = \alpha_0 + \alpha_1 Y_t + \alpha_2 P_{rt}^G + \alpha_3 P_t^{KSO} + \alpha_4 P_t^{ELER} + \alpha_4 P_t^{FW} + \alpha_5 G_{rt-1}^D + u_{rt}$$

Where:  $G_{rt}^D$  = residential natural gas demand  
 $Y_t$  = per capita real income  
 $P_{rt}^G$  = real price of natural gas  
 $P_{rt}^{KSO}$  = real price of kerosene oil  
 $P_t^{ELER}$  = real price of residential sector electricity  
 $P_t^{FW}$  = real price of firewood  
 $G_{rt-1}^D$  = lagged dependent  
 $u_{rt}$  = error term

Results:

- ✓ Per capita real income exerts a positive and significant impact on NG consumption in short and long run
- ✓ Price elasticities are low and generally inelastic for residential, while elasticities for the power sector are larger and price elastic
- ✓ Cross price elasticities indicates weak relationship between natural gas and querosene. Same is the case with natural gas vs electricity for residential and commercial sectors

# Modeling and forecasting natural gas demand in Bangladesh

Wadud et al – Energy Policy 39 (2011)

- ✓ Forecast natural gas demand in Bangladesh
- ✓ Natural gas is the main fuel source for both primary energy and power
- ✓ Develops a dynamic econometric model using data from 1981 to 2008 which.

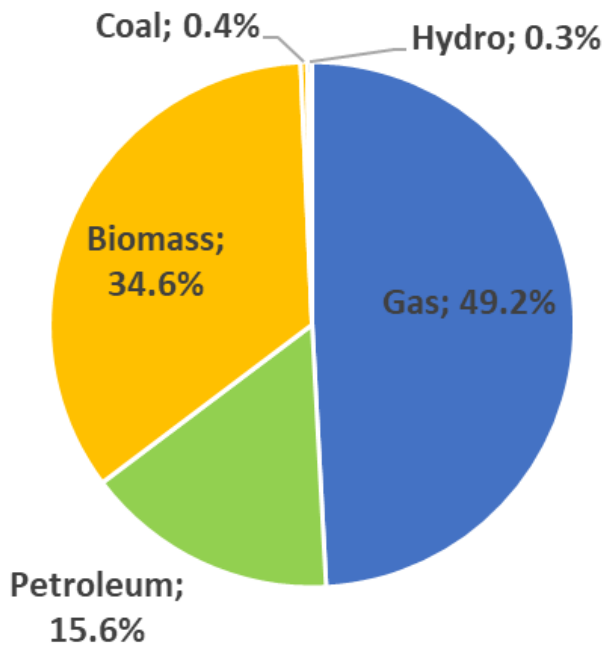


Fig.1 : Share of the primary energy source, 2005

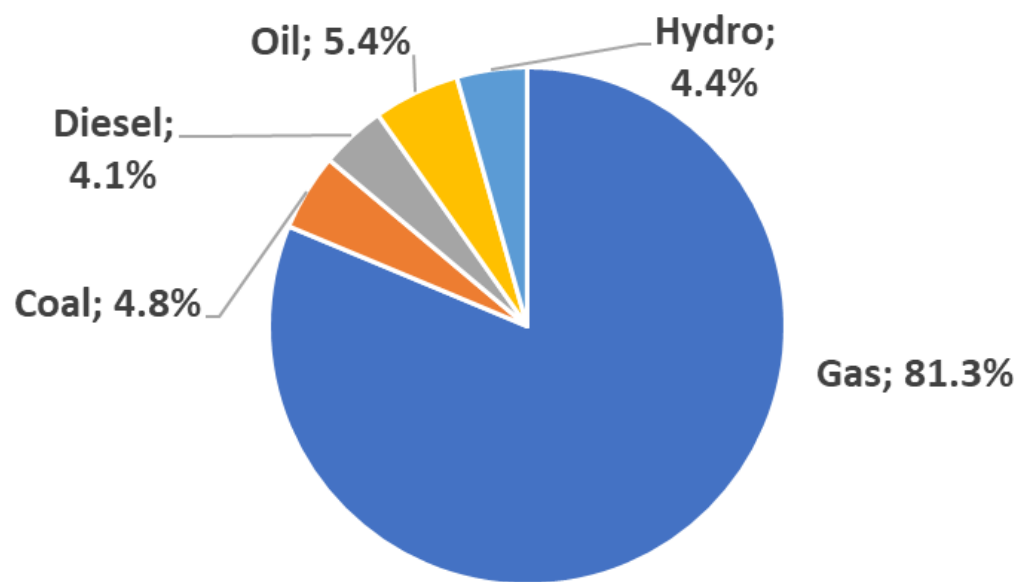


Fig.2 : Share of the fuels used for power energy, 2006-2007

# Modeling and forecasting natural gas demand in Bangladesh

Wadud et al – Energy Policy 39 (2011)

Model:  $\ln \text{Gas}_t = \kappa + \alpha \ln \text{Price}_t + \beta \ln \text{GDP}_t + [\gamma \ln \text{Population}_t] + \varepsilon_t$

Where:

$\text{Gas}_t$	= natural gas demand
$\text{Price}_t$	= real price of natural gas
$\text{GDP}_t$	= real gross domestic product
$\text{Population}_t$	= population
$\varepsilon_t$	= error term

Results:

- ✓ Statistically insignificant response of NG demand in respect to changes in price and population
- ✓ However, in the long run the model indicates a large response in NG demand with respect to GDP/income



# Summary

- ✓ Context of residential NG demand in Brazil
- ✓ Brief literature review on residential NG
- ✓ Challenges: selecting variables and gathering data

Our challenge will be to choose and test some of these variables in our forecasting model, aiming to explain the residential NG demand behaviour in Brazil

- ✓ price of natural gas ( $Price_t$ ) ?
- ✓ real gross domestic product ( $GDP_t$ ) ?
- ✓ per capita income ( $GDP_t/Pop_t$ ) ?
- ✓ net increase in population ( $Pop_t$ ) ?
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**THANK YOU**



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