


Demand Response Potential in Brazil: Theoretical Assessment

Smart Energy Systems Conference - 2019



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OUTLINE

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INTRODUCTION

METHODOLOGY

RESULTS AND DISCUSSION

CONCLUSION & OUTLOOK

INTRODUCTION

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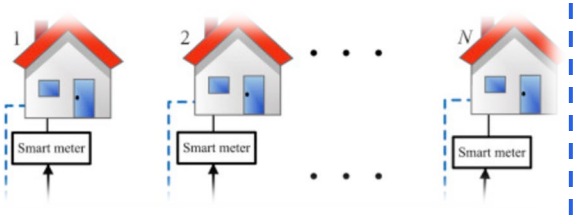
Main pillars towards a sustainable energy future

SUPPLY-SIDE

DEMAND-SIDE



Challenge: High growth of **Variable Renewable Electricity (VI**

Possible solution: Enhance the grid **FLEXIBILITY**, e.g., through DSM

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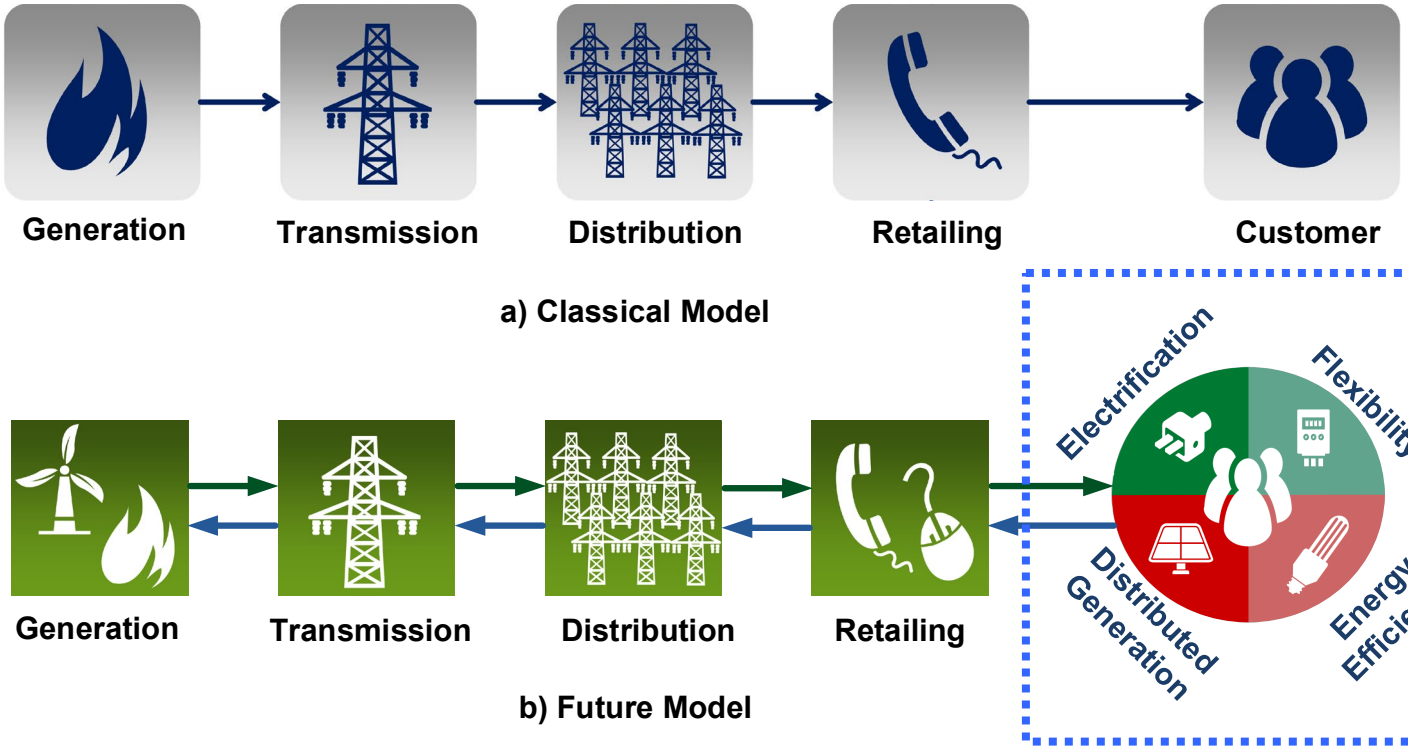
Classical and Future Model of the Electricity System



Consumers will play a key role in the electricity market in the future

→ DEMAND-SIDE MANAGEMENT

1. Demand-response(DR)

2. Energy Efficiency (EE)

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- **Evolution of smart grids >** Growing market share of smart appliances

Smart Grids may strongly facilitate the insertion of demand-side resources such as air conditioning and washing machines without compromising user comfort

- **Brazil:** The number of households in Brazil is expected to increase about 40 million in 2050 comparatively to 2012
  - **Currently:** Only a few DR programs

INTRODUCTION

- **Most of the previous studies**
- Focus on qualitative assessments
- Few works addressing
  - (1) the assessment of the theoretical DR potential in the Brazilian power sector and
  - (2) the existing analysis focuses on specific sectors and/or regions within the country

We quantitatively assess the theoretical DR potential for the specific case of Brazil

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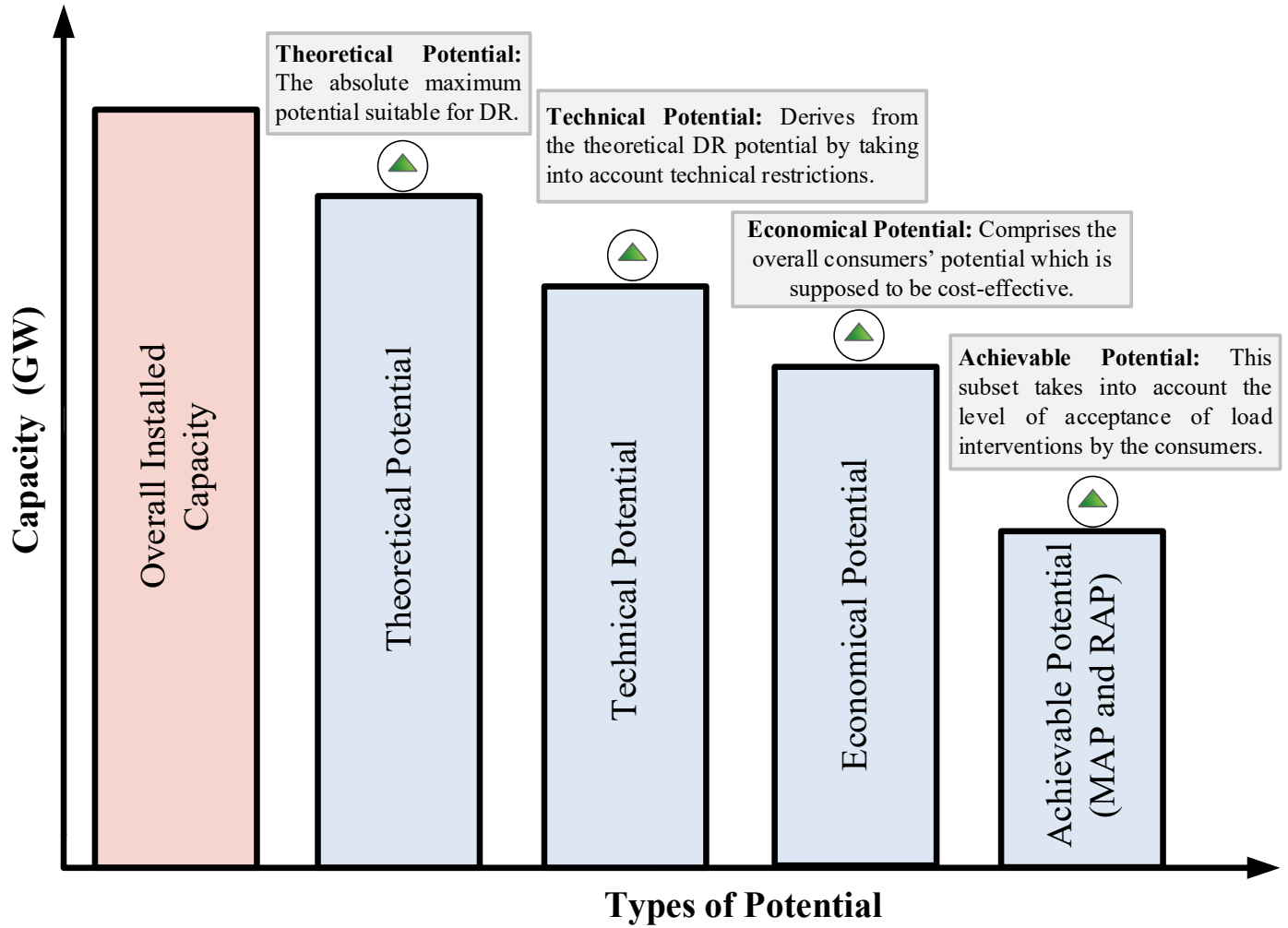
- Different categories of DR potentials



METHODOLOGY

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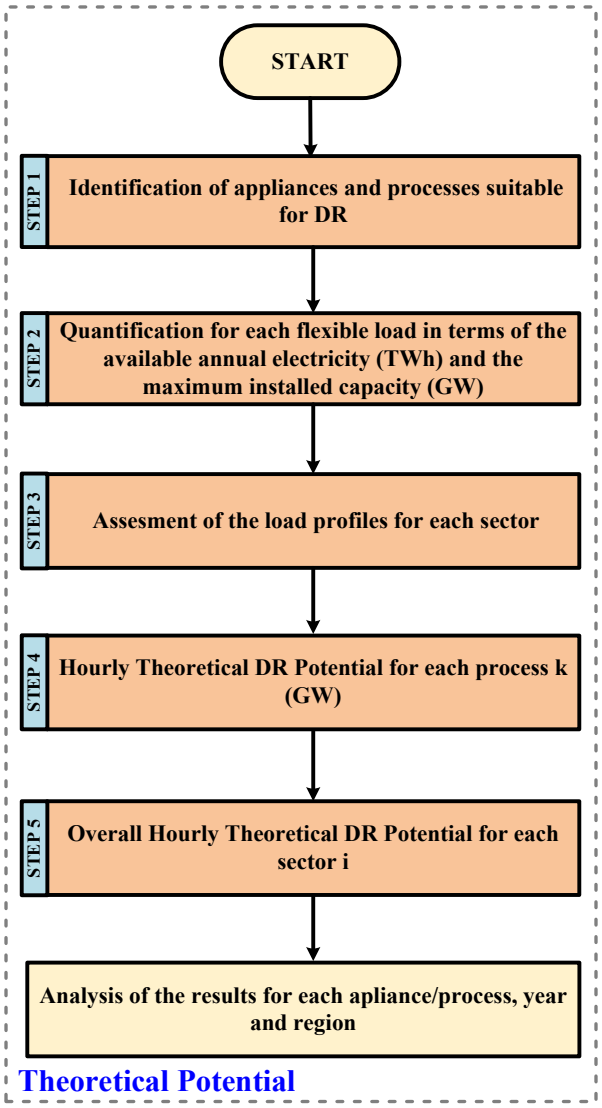
GENERAL METHODOLOGY OVERVIEW



- **Load shedding:** Industry
- **Load shifting:** Residential and Commercia

Table 2: DR applications selected to be considered in this study.

Energy-Intensive Industries	DR Action	Commercial	DR Action
Bauxite	Shedding	Air-conditioning/ cooling	Shifting
Alumina	Shedding	Direct Heating	Shifting
Primary Aluminum	Shedding	Storage water heater	Shifting
Iron and Steel	Shedding	**Residential**	**DR Action**
Ferroalloys	Shedding	Freezer	Shifting
Soda	Shifting	Refrigerator	Shifting
Petrochemical	Shifting	Washing machine	Shifting
Cellulose	Shifting	Laundry dryers	Shifting
Paper Machines	Shifting	Dishwashers	Shifting
Cement mills	Shifting	Air Conditioning	Shifting

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Table 3: Projected Number of Households (Million).

Region	2017	2020	2030	2040	2050	Reference
NE	18.3	19.3	22.1	24.4	26.7	[3,31]
NO	6.1	6.4	7.3	8.1	8.9	[3,31]
SE/CO	33.6	35.3	40.5	44.7	48.9	[3,31]
NO	9.6	10.1	11.6	12.8	14.0	[3,31]
Total	**67.7**	**71.1**	**81.5**	**90.0**	**98.5**	-

Table 4: Equipment Rate (%).

Equipment	2017	2020	2030	2040	2050	Reference
Freezer	18.0%	15.4%	14.6%	13.3%	12.0%	[3]
Refrigerator	110.0%	110.6%	112.0%	112.0%	112.0%	[31]
Washing Machine	69.0%	74.4%	81.0%	87.5%	94.0%	[3]
Laundry Dryers	6.9%	7.2%	8.2%	9.4%	10.8%	-
Dishwashers	2.0%	2.1%	2.4%	2.7%	3.1%	-
Air Conditioning	42.0%	46.2%	60.7%	62.8%	65.0%	[3]

Table 5: Specific Energy Consumption (kWh/Equipment).

Equipment	2017	2020	2030	2040	2050	Reference
Freezer	479	466	425	388	354	[31]
Refrigerator	329	323	303	285	268	[31]
Washing Machine	64	63	59	55	51	[31]
Laundry Dryers	308	314	336	360	385	[30]
Dishwashers	272	277	297	318	340	[30]
Air Conditioning	636	627	598	571	545	[31]

Table 6: Other input data.

Industrial Sector	Value
Revision outages (%)	5%
Capacity utilization level (%)	90%
Number of hours in a year	8760
Flexible share (%)	100%
Commercial Sector	**Value**
Annual Growth (%) - 2017-2020	5.1%
Annual Growth (%) - 2020-2030	5.2%
Annual Growth (%) - 2030-2040	4.4%
Annual Growth (%) - 2040-2050	4.5%
Number of full load hours	5840

RESULTS

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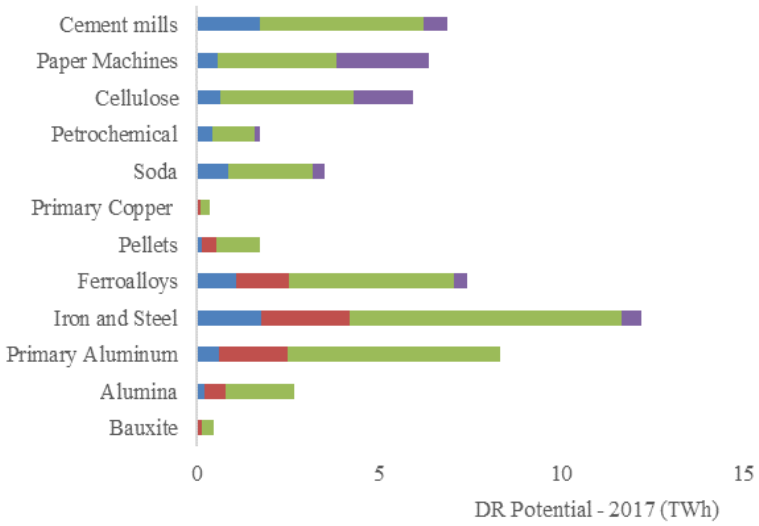
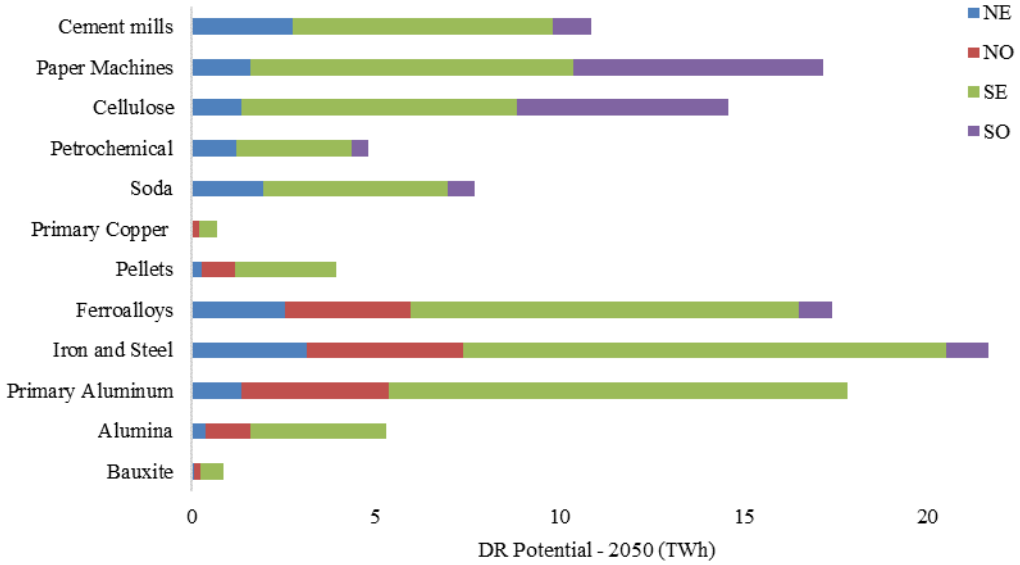
- **Industrial sector (load shedding + load shifting) - TWh**





- ✓ Load shedding potential increases by 102% (2017-2050)
- ✓ Load shifting potential increases by 115% (2017-2050)
- ✓ Wide disparity between the DR potentials for each region
- ✓ Higher contribution: Southwest region

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- **Industrial sector (load shedding + load shifting) - GW**

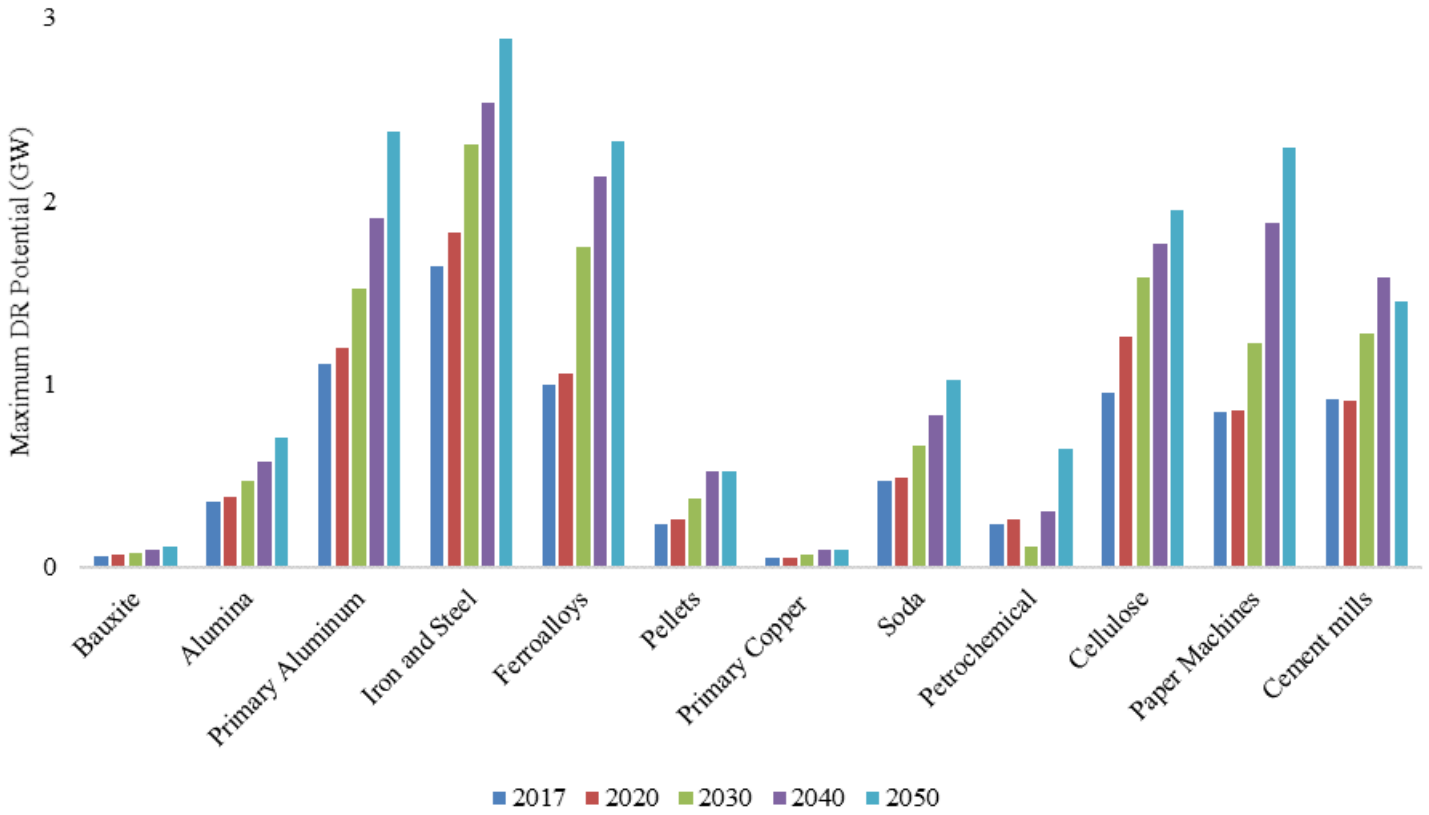

Fig. 5. Maximum DR potential for each energy-intensive industrial process (GW).

✓ **Increase from 7.9 GW to 16.4 GW (2017-2050)**

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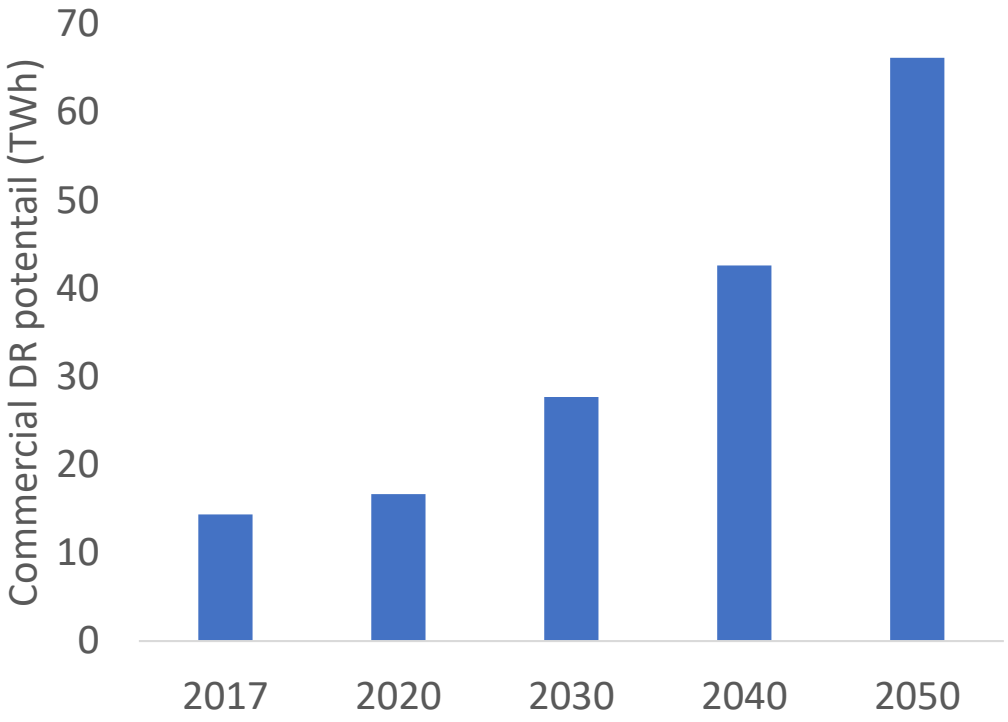
- **Commercial sector (load shifting)**



- ✓ Lack of detailed data
- ✓ Air-conditioning represents the highest contribution
- ✓ DR potential more than quadruple (2017-2050)

Fig. 6. Overall DR potential (load shifting) for commercial processes (TWh).

RESULTS

Commercial sector

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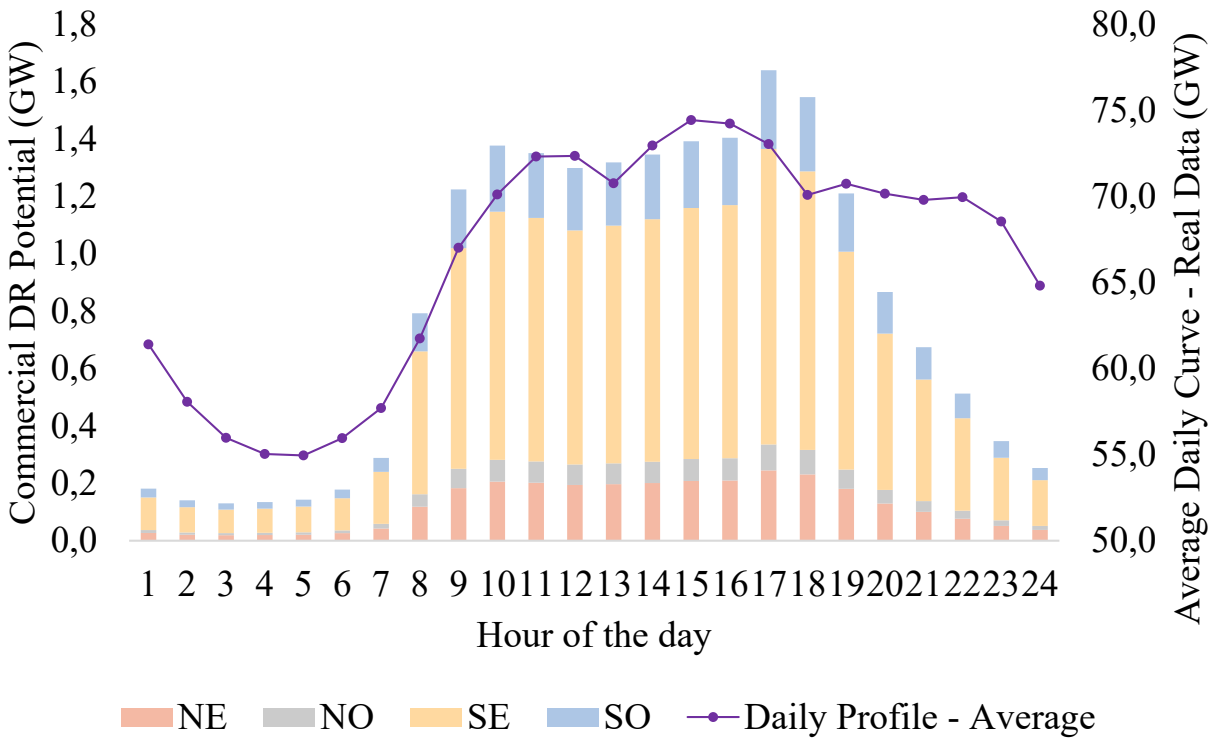

Fig. 7. Overall DR potential for each commercial process (left axis) and the average daily load curve (right axis).

- ✓ **Maximum hourly DR capacity**
- ✓ **Variation between 0.1 GW to 1.6 GW across a typical day**
- ✓ **Due to the limited commercial activity at night, the DR potential at this period is very limited**
- ✓ **DR availability for the commercial sector best matches the daily load curve**

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- **Residential sector (load shifting)**
  - ✓ DR availability is limited during on-peak times (15 p.m. – 16 p.m.)

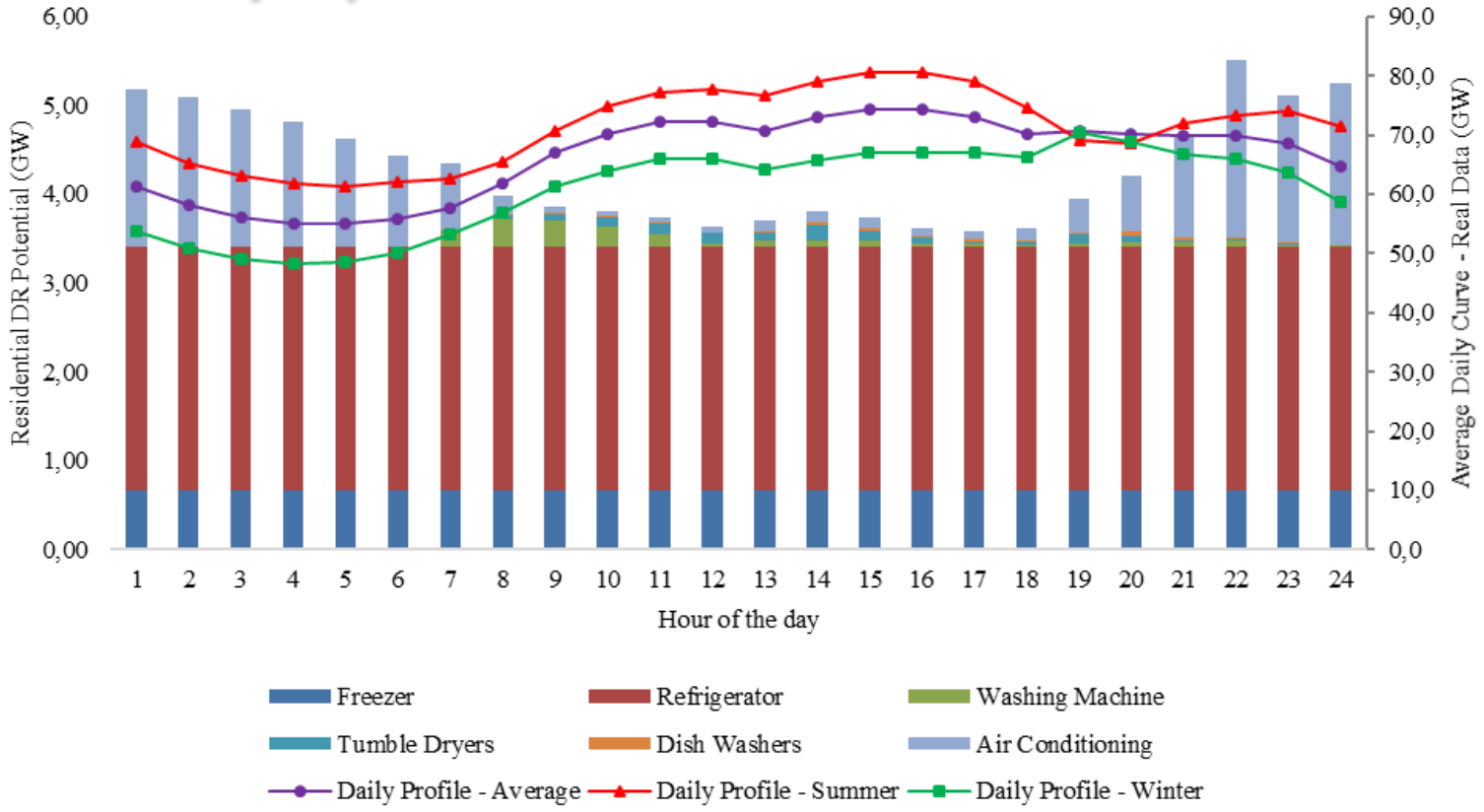

Fig. 9. Overall hourly DR potential for each appliance in the residential sector (left axis) and the average daily load curve of the interconnected power system (right axis) (in GW for 2017).

RESULTS

- **Residential sector (load shifting)**

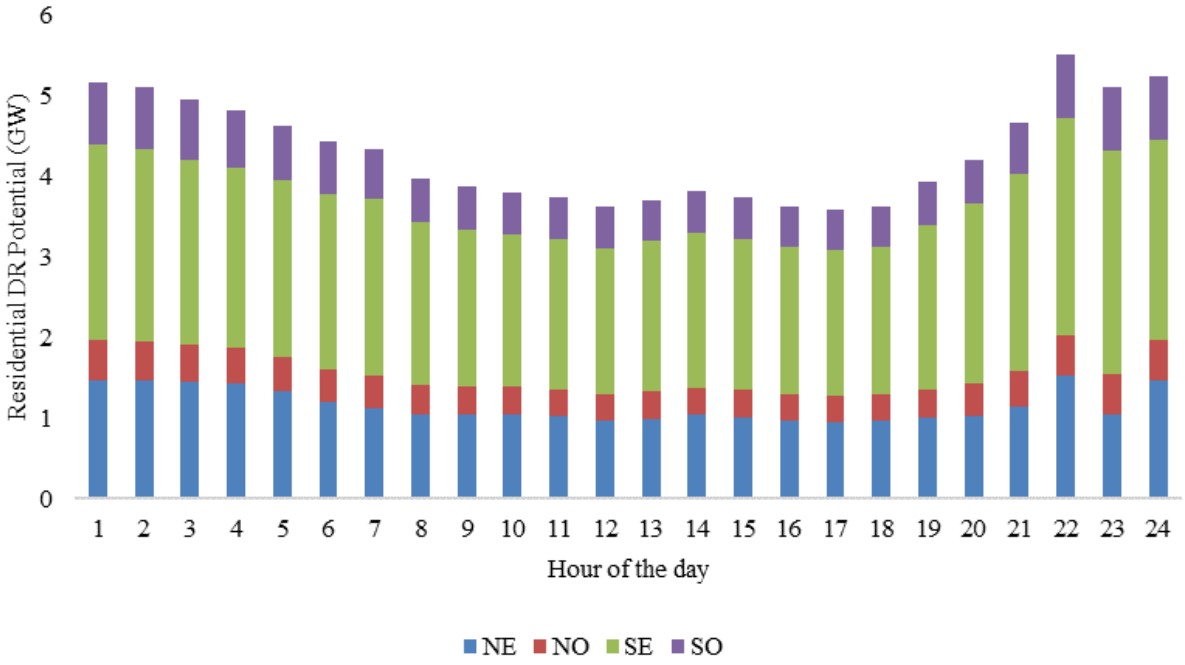

Fig. 8. Overall hourly DR Potential for each region in the residential sector - 2017 (GW).

- ✓ **Higher DR potential for Southwest**
- ✓ **Highest DR potential in a day: 5.5 GW (22 p.m.)**

CONCLUSION

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- The **theoretical DR potential** is assessed for the Brazilian power system
- The results include a **sectoral** and **regional** analysis
- The **majority demand-side response** potential may lie in the **industrial sector**
- **Lower** but a still substantial **potential for the residential sector** was also identified
- The maximum theoretical DR potential is expected to double between 2017 and 2050 (12.8 GW to 25.6 GW)
- In further research, other DR potentials should be addressed (e.g., technical, economic and achievable)

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Thank you for your attention!

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