



## Options for Resilient and Flexible Power Systems in Select South American Economies

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# A little bit about me

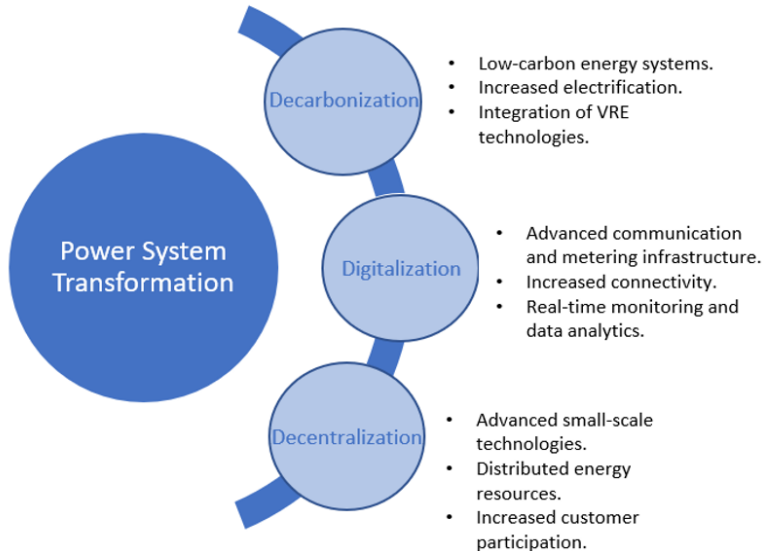
- I am originally from Brazil.
- Recently earned a Ph.D. in Electrical Engineering - University of Nebraska-Lincoln.
- Graduate intern at the National Renewable Energy Laboratory (NREL) (2018-2019).
- Currently on a collaborative appointment with NREL.
- I will join Washington State University in Fall 2020 – Assistant Professor of Electrical Engineering
- Research interests include power systems planning and optimization, electricity markets, renewable energy, and mathematical optimization.

## My Experience at NREL

- I worked with brilliant people with great expertise in energy systems.
- I had the opportunity to work in international projects and travel to four countries (Argentina, Brazil, Chile, and Colombia).
- I also had the opportunity to meet and interact with researchers with great expertise in other research areas such as big data, cybersecurity, and geospatial analysis.
- I developed several technical skills such as project management, technical writing, data analysis and public speaking.

# Global Power System Transformation

- Power systems around the globe are changing rapidly due to a confluence of technological, social, meteorological, and economic drivers.
- These changes are highlighting the need for flexibility in energy systems.



- Flexibility addresses different issues that span timescales that range from sub-seconds to years.

Type	Short-term			Medium-term	Long-term	
Timescale	Subseconds to seconds	Seconds to minutes	Minutes to hours	Hours to days	Days to months	Months to years
Issue to be addressed	System stability (large disturbances)	Quick fluctuations in the balance of supply and demand	Ramps in the balance of supply and demand	Decisions on the number of thermal plants to remain running	Schedule maintenance of power plants / Seasonal availability of some plants	Seasonal and inter-annual balance of generation and demand

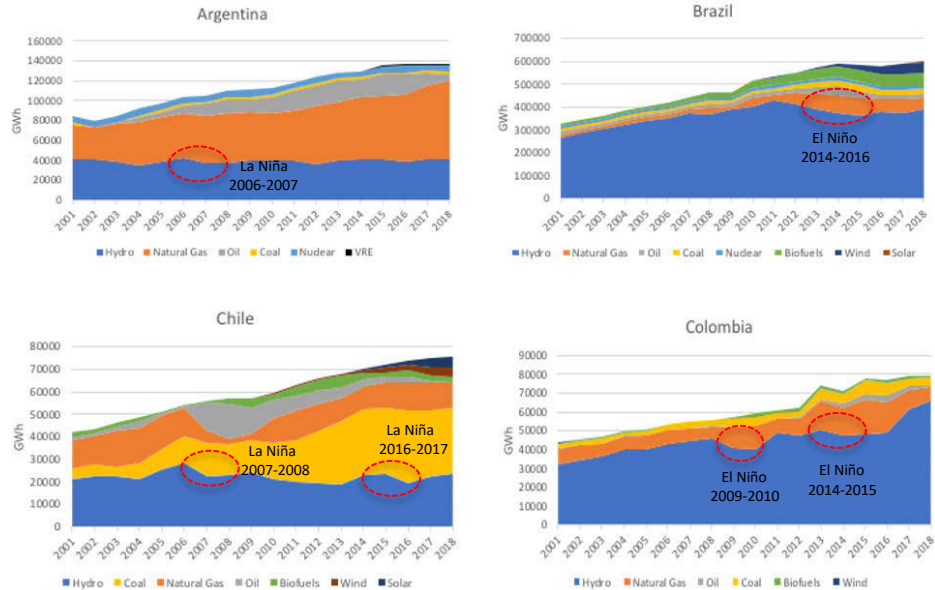
# Need for Flexibility in South American Countries

- Select South American countries that traditionally relied heavily on large (dammed) hydropower face increasing risk and reliability concerns during El Niño and La Niña hydrological phases.
- They also see rapid growth in VRE sources.
- There is an increasing need to expand emphasis on flexibility and resiliency at different time scales.
- In this study, special attention is placed on the potential role for natural gas to help ensure flexible and resilient power.
- Primary countries of focus:

- Argentina
- Brazil
- Chile
- Colombia



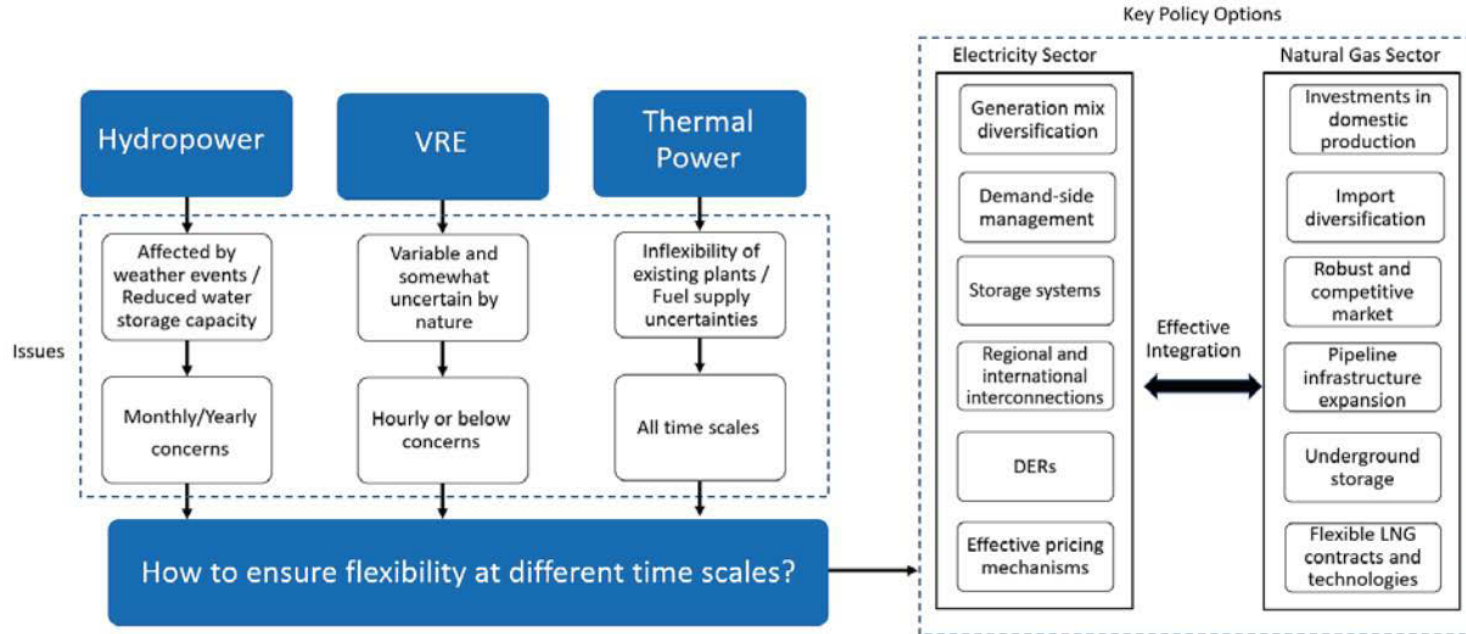
**Evolving generation mixes in Argentina, Brazil, Chile, and Colombia:**



Source: Data from CAMMESA, CNE, EPE, IEA, and XM.

# Need for Flexibility in South American Countries

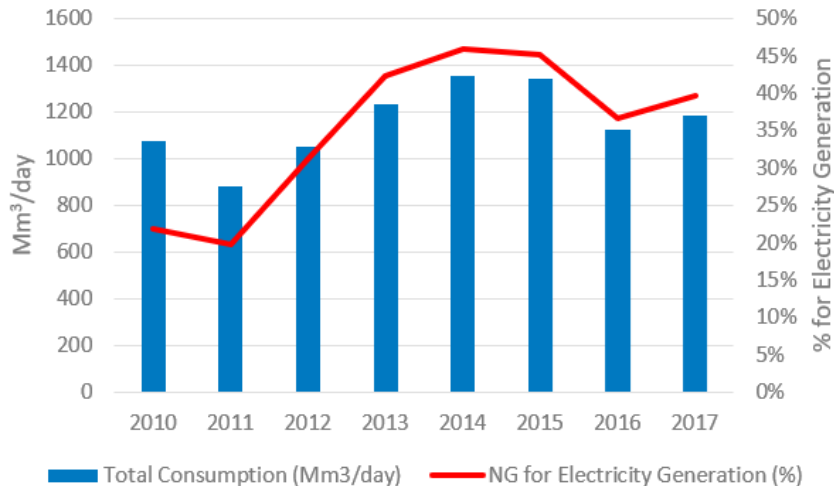
## Flexibility issues and options in power systems of key South American countries:



# Natural Gas as an Increasingly Important Generation Option

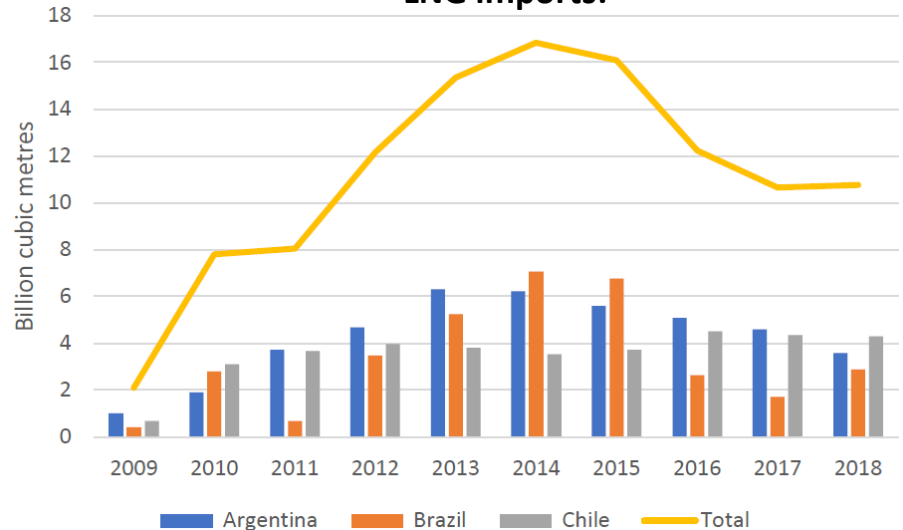
- Increasing natural gas consumption for electricity generation in South America.
- Contract terms for markets in LNG have become more liquid and flexible over the past five years.
- Alternatives to land-based LNG infrastructure have allowed South American countries to enjoy the benefits of short-term natural gas use without the need to invest in permanent land-based infrastructure.

**Total natural gas consumption:**



Source: Data from IAPG (2019), MME (2019), CNE (2019), and PROMIGAS (2019).

**LNG imports:**



Source: Data from GIIGNL (2019).

# Summary of Findings

## Risks and constraints for more flexible power generation in Select South American countries:

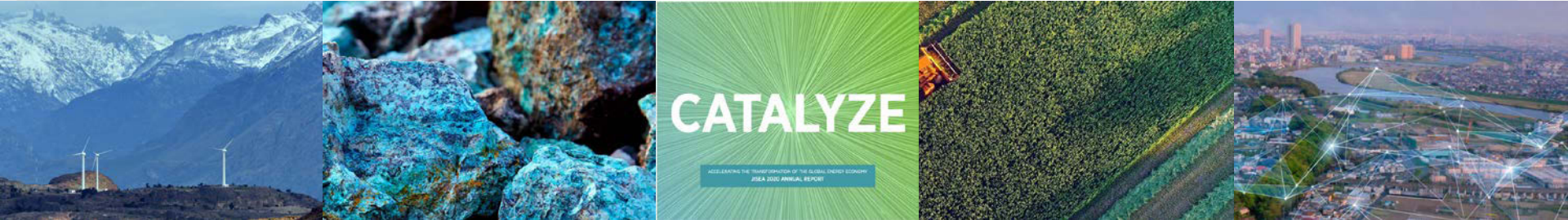
		<b>Argentina</b>	<b>Brazil</b>	<b>Chile</b>	<b>Colombia</b>
<b>Flexibility Catalysts</b>	Weather events affecting hydropower	Medium	High	Medium	High
	Increasing adoption of run-of-the-river power plants	Medium	High	Medium-High	High
	Increasing VRE integration	Medium	High	High	Low
	Thermal power generation inflexibility	High	Low	High	High
	Fuel-supply uncertainties	High	Medium	Medium	Medium

# Summary of Findings

## Barriers and challenges for electricity and natural gas development:

	Issue	Argentina	Brazil	Chile	Colombia
Relative barriers and challenges in the electricity sector	Aging infrastructure	X			
	Transmission capacity limitations	X	X	X	X
	Insufficient revenue for investment	X			
	Public opposition to hydropower plants	X	X	X	X
	Limited international interconnections			X	X
	Lack of market mechanisms to promote greater flexibility	X	X	X	X
	Demand concentration in specific regions	X		X	
Relative barriers and challenges in the natural gas sector	Techno-economic challenges associated with domestic production		X		
	Insufficient long-term domestic reserves			X	
	Lack of underground storage infrastructure	X	X	X	X
	Pipeline capacity limitations	X	X	X	X
	Insufficient revenue for investment	X			





# Thank you

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The full report from this study is available at:  
<https://www.nrel.gov/docs/fy20osti/75431.pdf>

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[www.jisea.org](http://www.jisea.org)

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