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Natural Gas and Renewable Energy Partnership

epe Empresa de Pesquisa Energética

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EPE (Energy Research Office)

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Empresa de Pesquisa Energética

Who we are

- Federal institution created in 2004
- Linked to the Ministry of Mines and Energy (100% public)
- Responsible for energy planning studies
- Supports the formulation, implementation and analysis of energy policies
- Team of > 300 people, mostly highly qualified analysts
- Based in Rio de Janeiro

Energy transitions

Long and complex process

- ❑ Economically-driven
- ❑ Technology-driven
- ❑ Policy-driven

Wood → Coal → Oil →

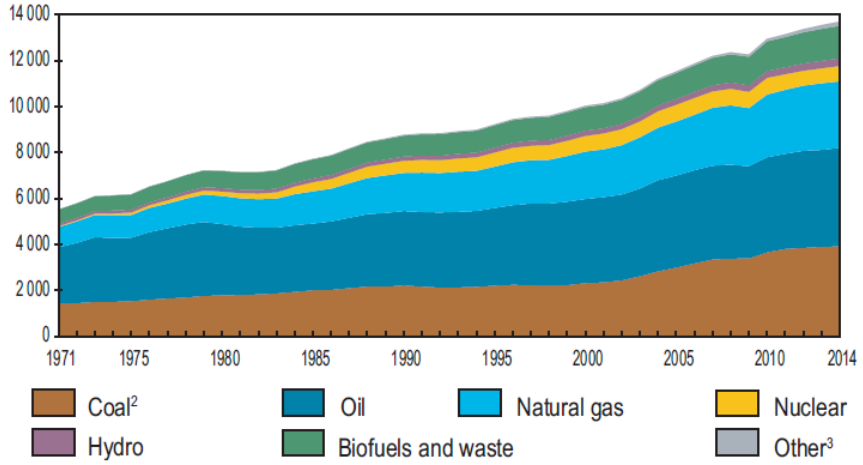
Natural Gas + Renewables

Natural Gas → Renewables

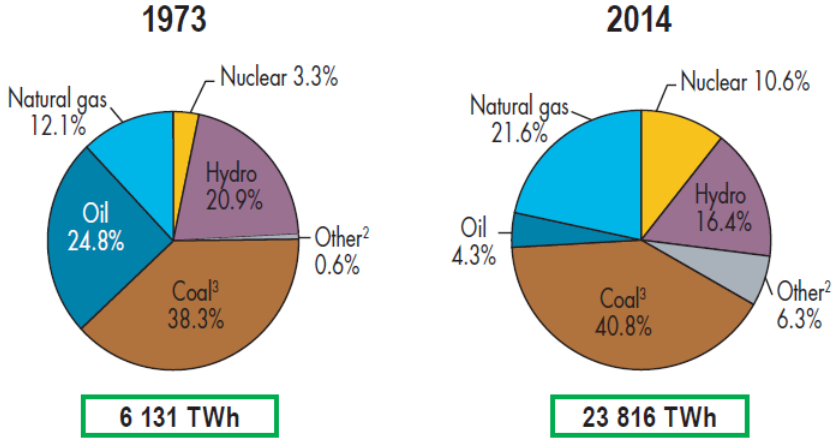
Energy Matrix

World outlook

World[1] total primary energy supply (TPES) from 1971 to 2014 by fuel (Mtoe)



World electricity generation[1] from 1971 to 2014 by fuel (TWh)



1. Excludes electricity generation from pumped storage.
2. Includes geothermal, solar, wind, heat, etc.
3. In these graphs, peat and oil shale are aggregated with coal.

Source: IEA – Key World Energy Statistics 2016

Energy Matrix

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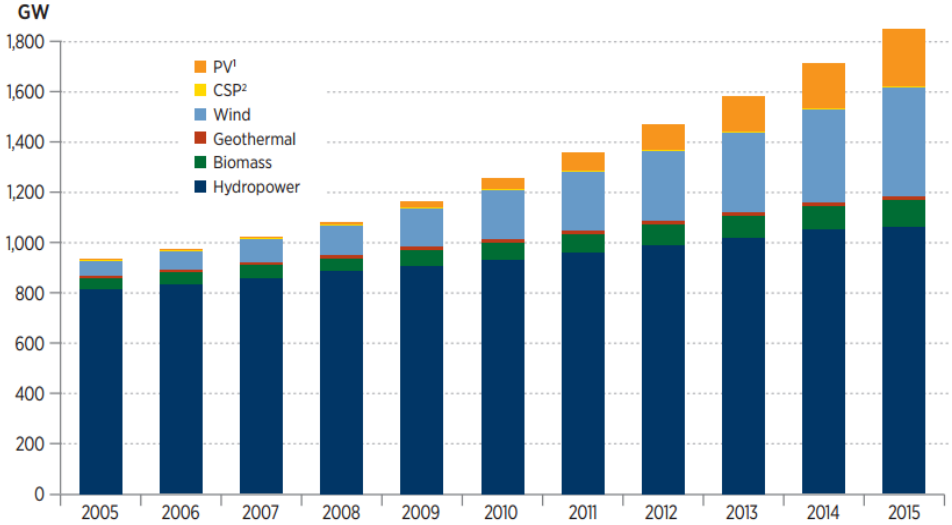
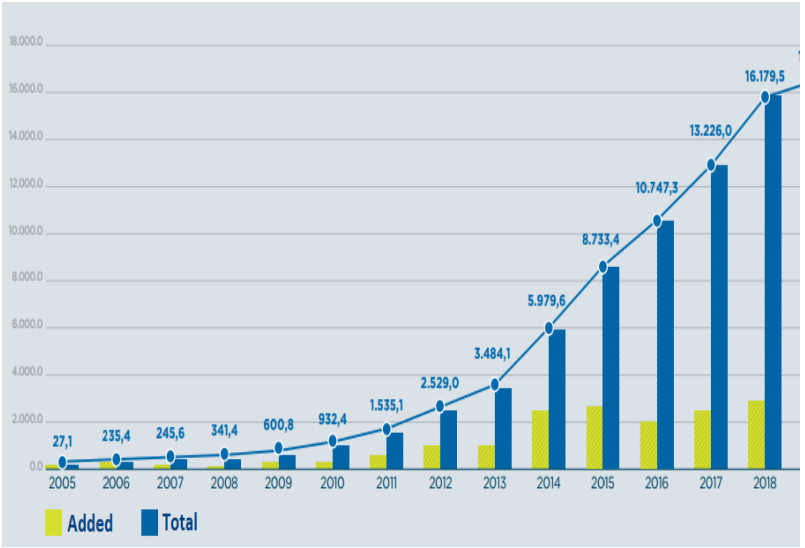
Rapid increase in variable renewable power

Global Renewable Electricity Capacity



Source: US DoE, 2015 Renewable Energy Data Book

Brazil: Wind Installed Capacity

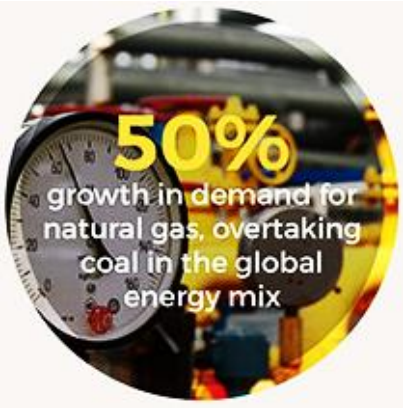


Source: ABEeólica

Energy Matrix

Projected numbers after the Paris Agreement

The energy sector in **2040** if countries abide by Paris Agreement pledges



Source: IEA – World Energy Outlook 2016

Variable Renewable Energy

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Relevant features

- ❑ Variability (non-dispatchable)
- ❑ Uncertainty
- ❑ Location-constrained and distributed
- ❑ Non-synchronous

How to plan power systems for the transition to renewables?

Long-term planning

Power system reliability

	Generation	Networks
Adequacy	Firm capacity	Transmission capacity
Security of operation	Flexibility	Voltage control capability
	Stability (frequency and voltage response)	

Source: IRENA (2017) – Planning for the Renewable Future

Long-term planning

*Need for **flexibility** and **firm capacity***

Residual Load

=

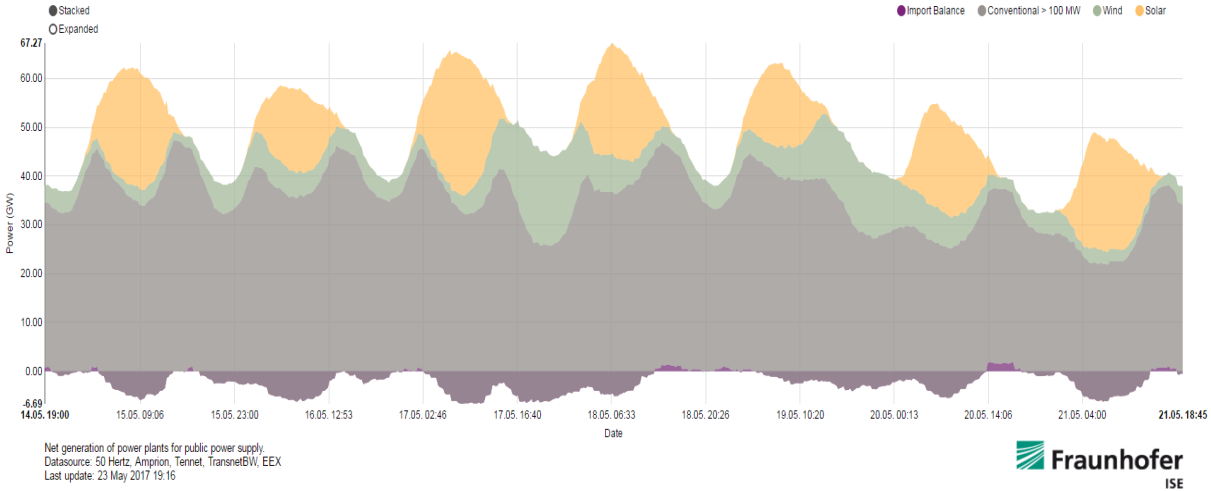
Demand
(variable and uncertain)

-

Variable Renewable Generation

Need for other resources in the power system to meet residual load

Electricity production in Germany in week 20/2017

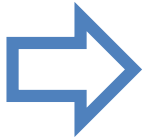


Source: Fraunhofer Institute for Solar Energy Systems ISE – www.energy-charts.de

Challenges of integration

Higher shares of renewables…

- As a consequence:
  - Residual load forecasting becomes less accurate
  - Increased cycling
  - Peaks in residual load profile become more pronounced in magnitude
  - load following ramps become more steep



- Conceptual solutions:
  - Higher allocation of operating and contingency reserves
  - Residual load profile smoothing
  - Additional flexible capacity

Challenges of integration

Higher shares of renewables…

- A range of practical solutions (balancing resources)
  - Additional flexible generation
  - Additional grid interconnections
  - Storage (i.e. reservoirs, batteries, chemical products…)
  - Demand side response
  - Variable generation curtailment
  - Load shedding (not a long-term solution)

Gas-fired power will be competing against many other solutions!

Challenges of integration

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Market design and regulation issues

- Cost reductions for renewables will not be enough to ensure an efficient decarbonisation of electricity supply → Imperfect incentive framework
- Very low renewable marginal costs impose significant challenge for investments in gas-fired plants
- Negative prices evidence the economic value of flexibility
- Scheduling mismatches (gas vs. power)

Power and Gas Industries

It used to be easier for gas-fired plants…

- Renewables disturb what used to be almost baseload generation → decline in running hours of gas-fired plants
- Need for more liquid wholesale gas market and available gas transport and storage infrastructure → high take-or-pay contracts not as suitable as before

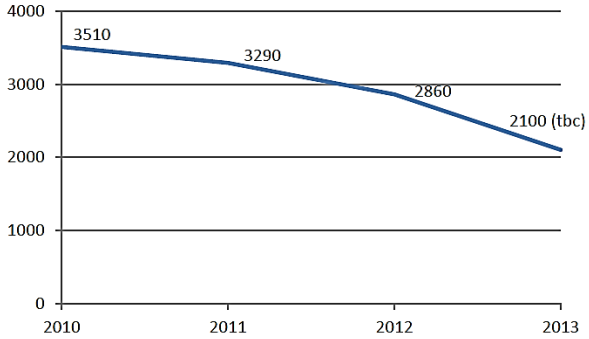
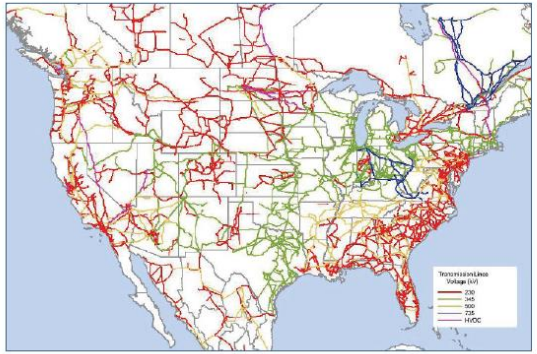


Figure 4 – German gas fired plants operating hours (Source: BDEW)

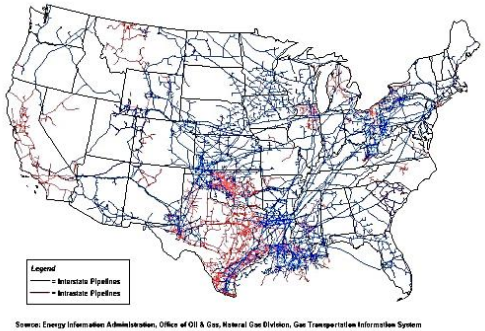
Power and Gas Industries

Developed networks increase liquidity

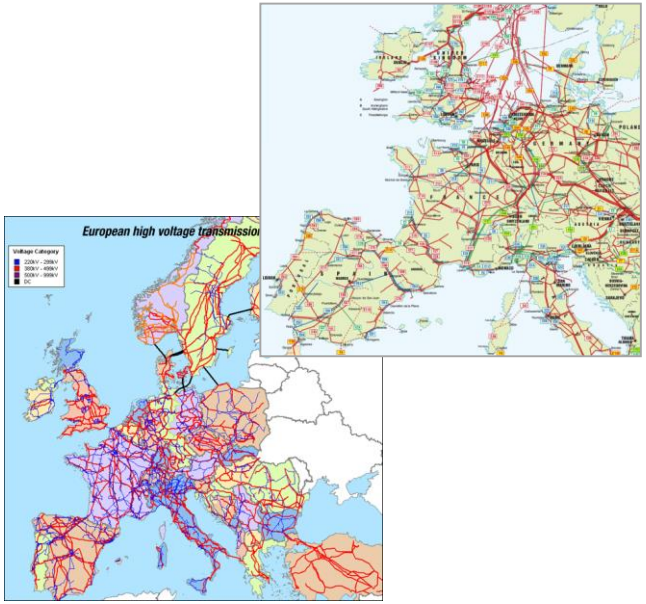
U.S. electric transmission grid[8]



U.S. gas pipeline infrastructure[7]



Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System



Power and Gas Industries

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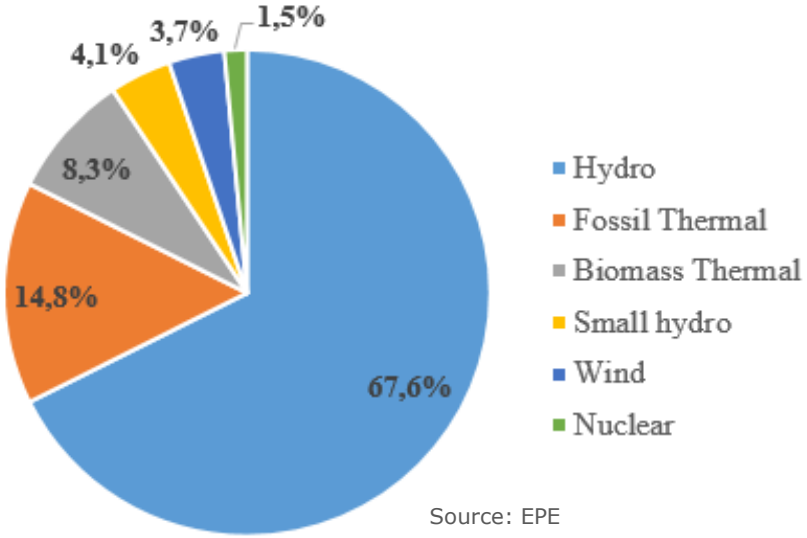
Natural gas industry is changing

- Natural gas infrastructure will need to be adapted → higher intermittency and periods of idleness
- Increased LNG shipments and a more global and flexible LNG market tend to improve gas security of supply
- Energy abundance era? At least for the USA

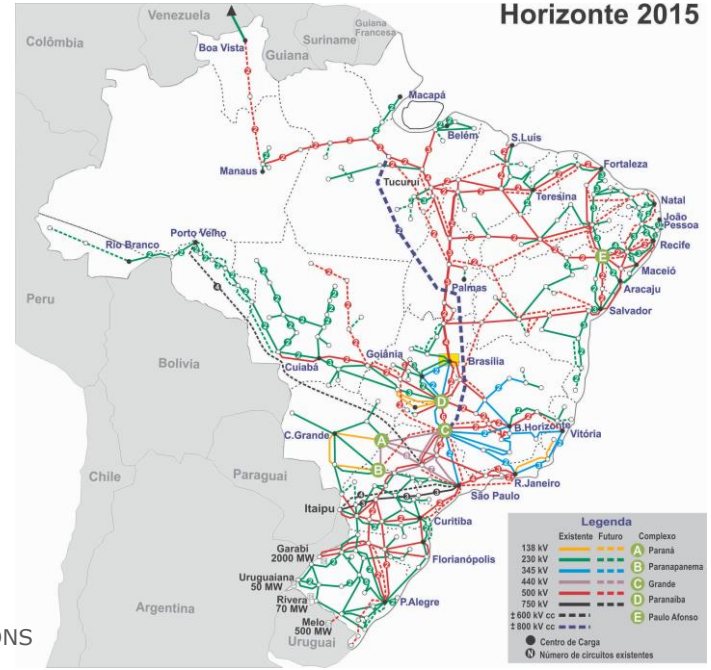
Electricity Markets

Brazil has its own issues…

Installed capacity 2014 (MW)



Source: EPE



Source: ONS

Electricity Markets

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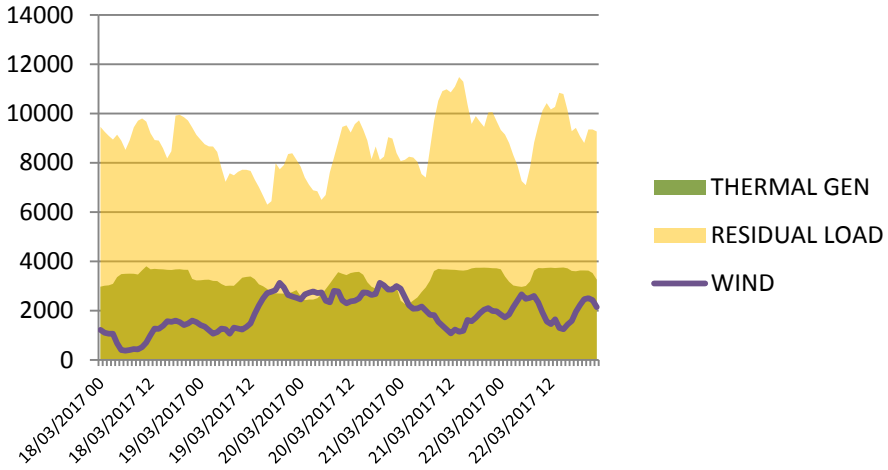
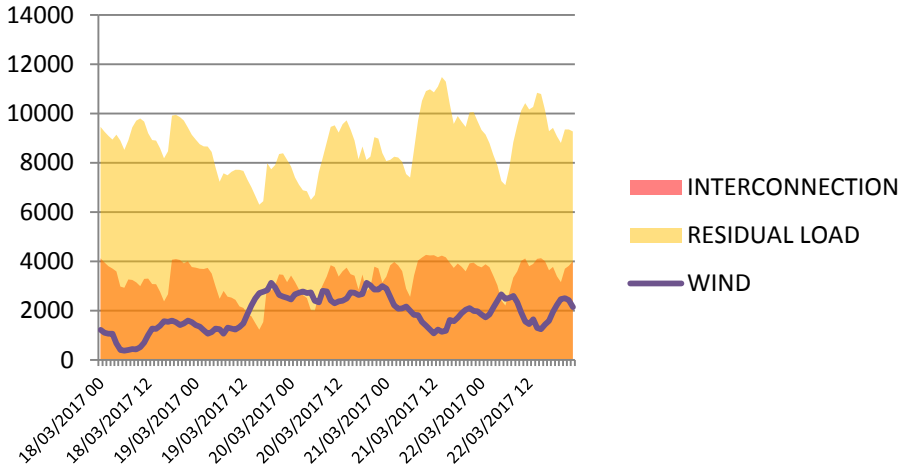
March 18th to 22nd 2017
Residual Load and Thermal Gen (MW)
Northeastern Brazil



March 18th to 22nd 2017
Residual Load and Imports (MW)
Northeastern Brazil



Source: ONS data

Electricity Markets

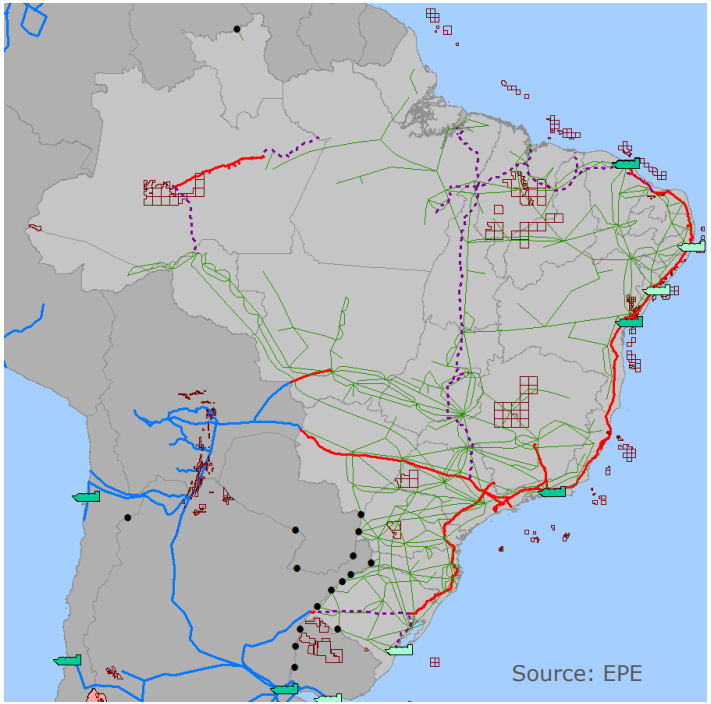
Brazil: General features

- Electric power system with a significant share of hydro generation
- Huge transmission grid > 135,000 km
- Capacity expansion rely mainly on long-term tendering contracts
- Electricity spot market with particular characteristics
  - Coarse temporal resolution (weekly) and dispatch based on computer models
  - High long-term price volatility (related to hydrology)
  - Thermal plants to define before construction its must-run levels
- Little incentive for ancillary services, including reserves

Natural Gas Markets

Brazil: Some notes

- Incipient natural gas market and infrastructure
- LNG capacity of 41 Million m³/day
- New gas-fired plants projected at the site of new LNG terminal (vertical integration, avoided transport pipeline costs)
- Uncertainty about pre-salt associated gas
- The role of Petrobras



Pathways for Brazil

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Options for gas-fired power plants

Flexible generation

- Fuel burned only when water resources are scarce → optimal use of resources and avoided spillages
- Load following to manage higher wind and solar capacity

Baseload generation

- Investor have to set its must-run level before construction, but today limited to 50%
- Lower contracted prices for gas (lower take-or-pay costs, higher efficiency: CC)

Investors concerns:

- Firm but flexible gas supply (including contractual clauses) → LNG, non-associated or storage
- Adequate remuneration for startups and load following
- Regulation better aligned with the practices of the natural gas industry

Final Remarks

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- There is no single solution for the problems associated with increasing shares of variable renewables;
- Gas-fired plants are competitive candidates for delivering flexibility and firm-capacity, immediately available for handling some of the consequences brought into power systems by variable renewables
- Infrastructure can be a bottleneck → need for investments under more flexible demand commitments

Final Remarks

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- Infrastructure will need to be enhanced, but market design is absolutely fundamental for cost-effective investment decisions → Brazil is discussing wide reform with "Gas to Grow" Initiative
- The economical and environmental optimization of resources will require:
  - **planning tools**: integrated approach for investment in infrastructure
  - **market design**: value correctly provided products/services and avoid subsidies
  - **regulatory framework**: adequate risk allocation

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