

TECHNICAL AND ECONOMIC ANALYSIS OF POTENTIAL GAS PIPELINES LINKED TO NEW LNG TERMINALS IN BRAZIL

Rio Pipeline 2019 – EPE Stand

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Agenda

- **Context**
- **Methodology**
 - Route Analyses
 - CAPEX & Tariff Estimation
 - Simulations
- **Pipelines Description & Results**
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 - Terminal Gás Sul – GASBOL
 - Porto Sergipe – Catu Pilar
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Context



Gas-to-Power model using LNG terminals on the coast has been successful at Energy Auction in Brazil.



The idle regasification capacity of the FSRU terminals could encourage stakeholders to find alternatives to monetizing such capacity by connecting the terminals to the grid.



OBJECTIVE

Analyze possible pipelines routes that originate from a new LNG terminal and connect to the transmission pipeline network, estimating their CAPEX, OPEX and tariff, besides testing through thermofluid-hydraulic simulations their impact on the integrated grid.

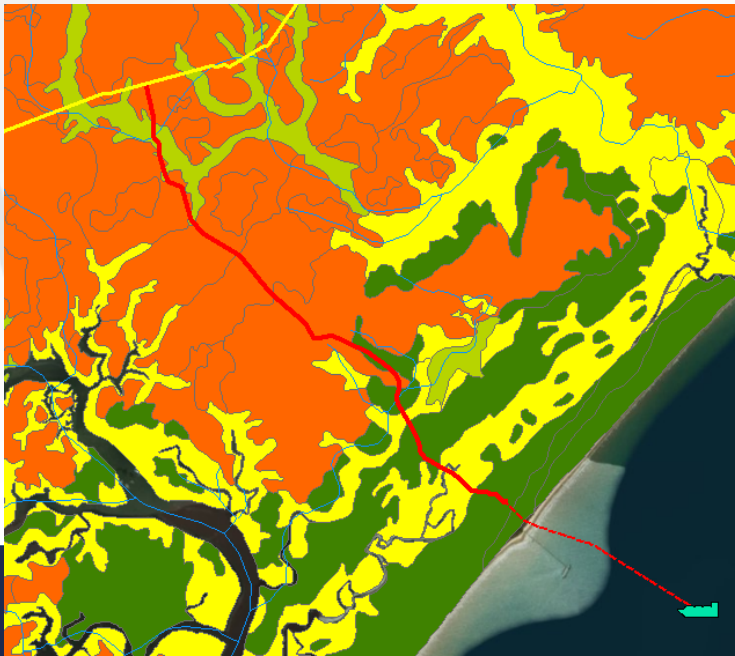
Route Analyses



ArcGIS

Main Premises

- Avoiding socio-environmental sensitive areas.
- More economical constructive difficulties available.
- ABNT Standards.
- Preference for sharing right-of-way.



CAPEX Estimation



Main Premises

- **SAGAS – Pipeline Cost Evaluation System**
- **Pipe** costs includes acquisition of the pipe, its coating, and freight up to the site of the work.
- **Components** costs includes the acquisition, construction and assembly of valves, launchers and receivers and cathodic protection system.
- **Construction and mounting** costs includes the preparation of the track, the construction and assembly of the pipeline and river/street crossings, and the commissioning of the pipeline, in addition to the trepanation service in the existing pipeline. It also includes local administration with costs of mobilization and demobilization and deployment of the construction site and costs regarding local inspection.
- **Complementary facilities** costs includes the acquisition and construction and assembly of measuring, compression, delivery and interconnection stations, as well as supervisory and control materials and services.
- **Supervision and control systems, communication and leak detection** costs includes materials and services of the SCADA system and the systems needed for pipeline and valve operation.
- **Terrain/right of way** costs includes land for the construction of the gas pipeline and point facilities (does not include rent of existing right of way).
- **Engineering project, environmental licensing and compensations** costs includes costs with feasibility studies, basic design, executive design and as built.

Tariff Estimation

Main Premises

- Postal tariff.
- Physical and financial schedule.
- Discounted Cash Flow analysis ($NVP = 0$).
- IRR of 9.67% per year for equity capital and 7.89% for third-party capital.
- The concession period was 30 years.
- Maximum capacity since year 1.
- OPEX 4% of the CAPEX.
- Cases which there is right-of-way sharing, rental was estimated by 10% of the cost of the land. The result was added to the default OPEX.



Source: Nati Harnik.

Simulations

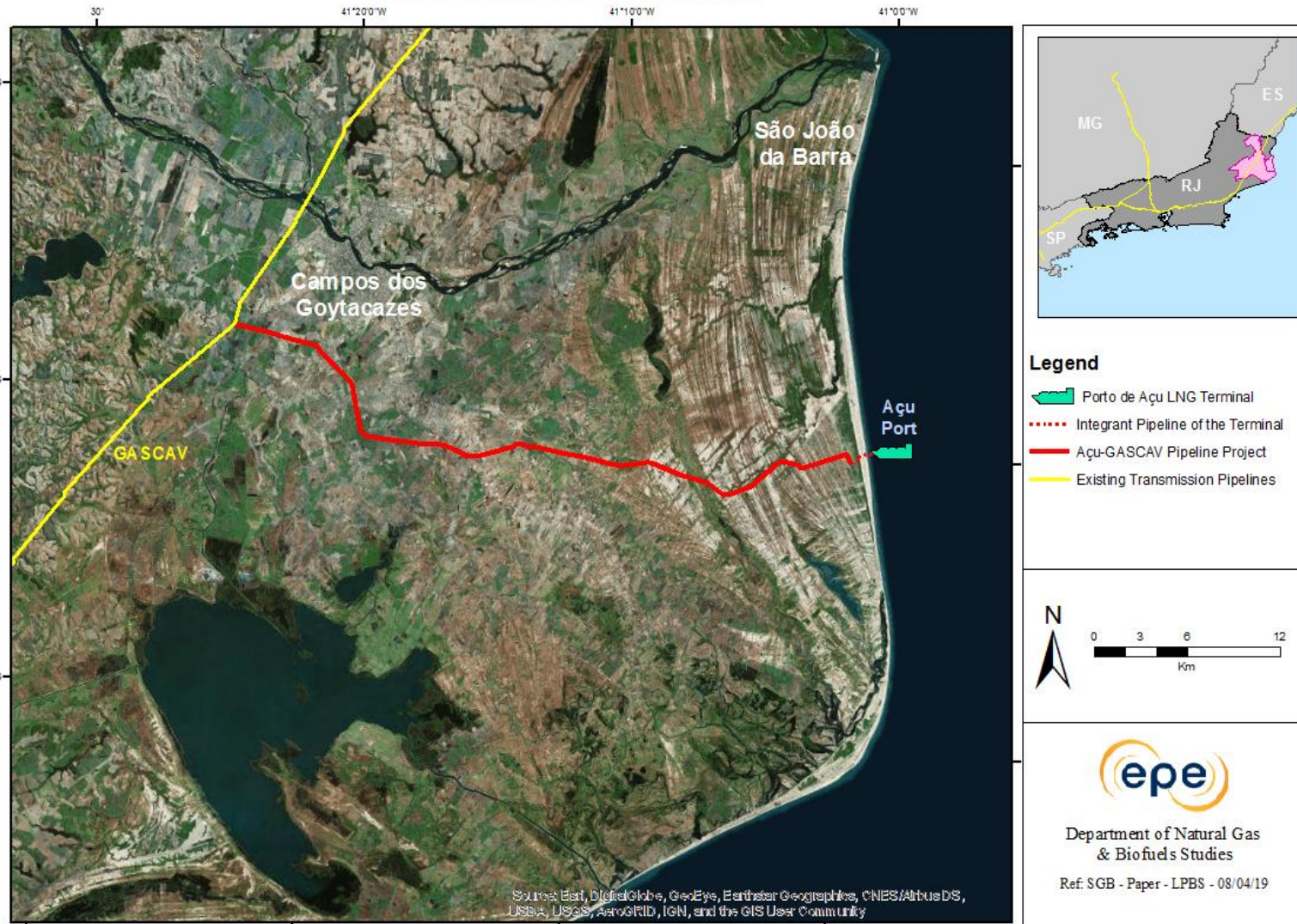


Main Premises

- Software: Pipeline Studios®
- Steady-state thermofluid-hydraulic.
- PDE integrated network grid model, sectioned by regions (Northeast, Southeast and GASBOL grid).
- All the proposed pipelines were tested individually in each respectively region.
- Supply and demand according to PDE 2027 (year 2023).
- The tests do not take into account price signals, neither contractual conditions for the purchase and sale of gas.

Porto do Açu - GASCAV

São João da Barra/RJ – Campos de Goytacazes/RJ



GENERAL

- Extension: 45.5 km
- Diameter: 18 in
- Max. Flow: 10 MMm³/day

ROUTE CHARACTERISTICS

- River Crossing: 1390 m
- Road Crossing: 1044 m
- Flooded Area: 2218 m
- Hard Rocks: 0 m
- Shared Right-of-Way: 0 m



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Ref: SGB - Paper - LPBS - 08/04/19

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Porto do Açu - GASCAV

Economic Aspects

Description	R\$ mi	%
Direct Costs		
Pipes	53.02	14.92%
Components	14.47	4.07%
Construction and Mounting	134.94	37.97 %
Complementary Facilities	9.54	2.68%
Supervision and Control Systems, Communication and Leak detection	8.00	2.25%
Terrain / Right-of-Way	26.48	7.45%
Indirect Costs		
Engineering Project, Compensation and Environmental Licensing	5.47	1.54%
Income and Indirect Expenses	53.38	15.02%
Contingencies	50.08	14.09%
TOTAL CAPEX (reference value, includes contingencies, June/19)	355.38	100%

OPEX defined: 4%

Tariff calculated:

US\$/MMBtu 0.12

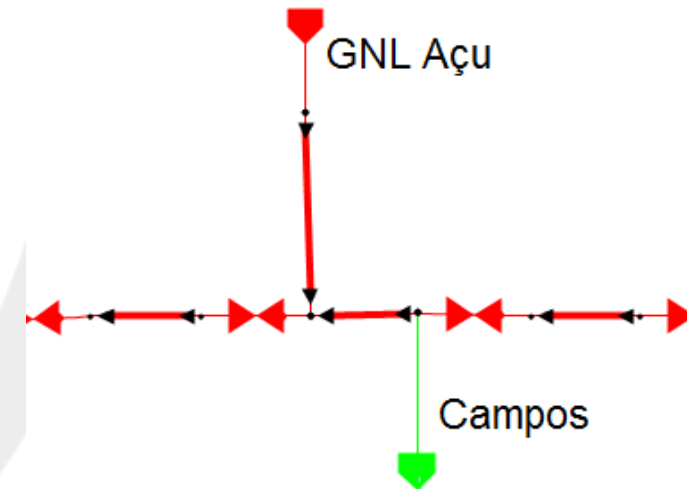
Note: estimates based on concept screening level analyses, with -20% to -50% and +30% to +100% precision.

Source: EPE.

Porto do Açu - GASCAV

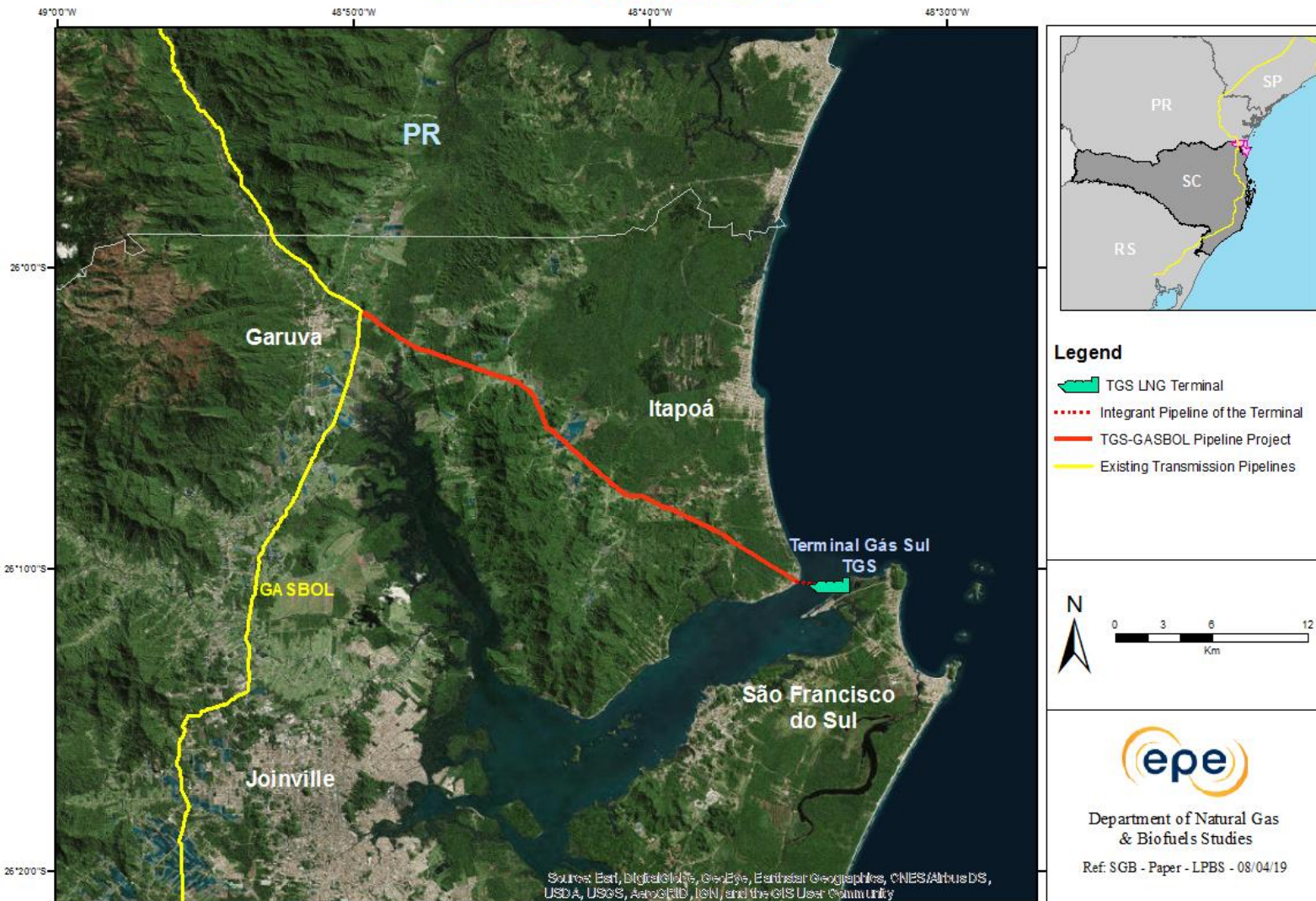
Results & Discussion

- The zone of influence of the Açu terminal would be similar to that of the Guanabara Bay terminal, which could bring some redundancy.
- For 2027, a considerable increment of gas supply from pre-salt is expected. Possibility of NGPP in the Açu Port.
- Considering the amount of pre-salt gas arriving at the coast, it could result in a necessity to disclose this gas to the integrated transmission network through a pipeline.
- The construction of a NGPP in the complex of Açu Port could be a facilitator to build the pipeline.
- The Açu terminal connection to the gas transmission network could work as a backup supply for the TPP in case of any setback from the FSRU supply while there is no NGPP in the complex.



Terminal Gás Sul - GASBOL

Itapoá/SC – Garuva/SC



GENERAL

- Extension: 31 km
- Diameter: 20 in
- Max. Flow: 15 MMm³/day

ROUTE CHARACTERISTICS

- River Crossing: 636 m
- Road Crossing: 760 m
- Flooded Area: 1770 m
- Hard Rocks: 12500 m
- Shared Right-of-Way: 31000 m



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Terminal Gás Sul - GASBOL

Economic Aspects

Description	R\$ mi	%
Direct Costs		
Pipes	42.80	13.62%
Components	14.31	4.55%
Construction and Mounting	142.86	45.46 %
Complementary Facilities	9.54	3.04%
Supervision and Control Systems, Communication and Leak detection	7.41	2.36%
Terrain / Right-of-Way	0.58	0.19%
Indirect Costs		
Engineering Project, Compensation and Environmental Licensing	4.31	1.37%
Income and Indirect Expenses	48.37	15.39%
Contingencies	44.09	14.03%
TOTAL CAPEX (reference value, includes contingencies, June/19)	314.28	100%

OPEX calculated: 4.46%

Tariff calculated:

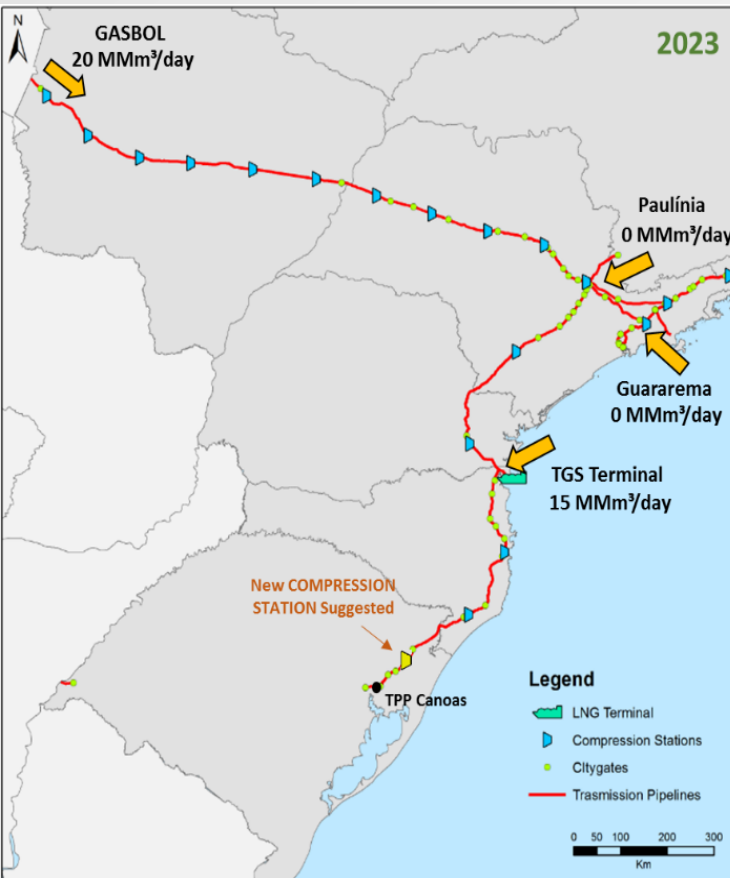
US\$/MMBtu 0.07

Note: estimates based on concept screening level analyses, with -20% to -50% and +30% to +100% precision.

Source: EPE.

Terminal Gás Sul - GASBOL

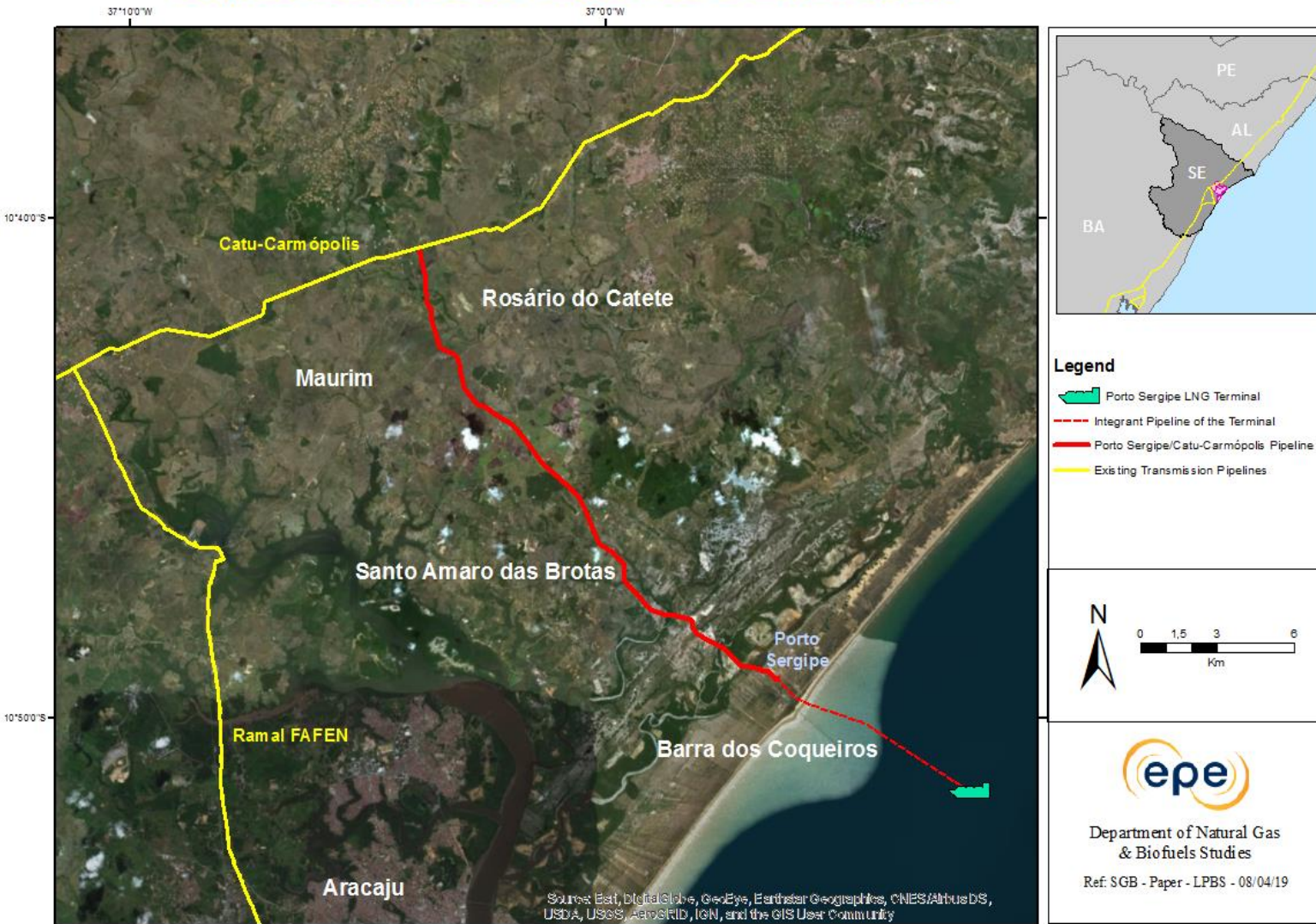
Simulation Results & Discussion



- More independence by the region on gas supply. Only Bolivia gas (20 MMm³/day from 2022 on) and TGS terminal were enough to supply all demand from GASBOL grid, in 2023, according to PDE 2027 data.
- However, due to GASBOL infrastructure limitations in the Rio Grande do Sul State, it might not be enough to operate the bi-fuel TPP Canoas (Sepé Tiarajú) together with the petrochemical pole of Triunfo (both in maximum capacity). One of the successful solutions tested was the addition of another compression station in the northern region of the State.
- The construction of this pipeline, together with all the adjustments in the grid mentioned, could bring some diversification of supply and develop potential gas markets in the Southern Region.
- The interconnection of the TGS terminal to the network could reduce gas price in the Southern Region when applied the entry-exit transmission tariff.

Porto Sergipe – Catu Pilar

Barra dos Coqueiros/SE – Rosário do Catete/SE



GENERAL

- Extension: 23.2 km
- Diameter: 18 in
- Max. Flow: 10 MMm³/day

ROUTE CHARACTERISTICS

- River Crossing: 678 m
- Road Crossing: 910 m
- Flooded Area: 460 m
- Hard Rocks: 0 m
- Shared Right-of-Way: 0 m



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Porto Sergipe – Catu Pilar

Economic Aspects

Description	R\$ mi	%
Direct Costs		
Pipes	30.48	11.06%
Components	14.47	5.19%
Construction and Mounting	94.55	34.29%
Complementary Facilities	9.54	3.46%
Supervision and Control Systems, Communication and Leak detection	7.17	2.60%
Terrain / Right-of-Way	32.74	11.88%
Indirect Costs		
Engineering Project, Compensation and Environmental Licensing	3.60	1.31%
Income and Indirect Expenses	45.08	16.35%
Contingencies	38.24	13.87%
TOTAL CAPEX (reference value, includes contingencies, June/19)	275.71	100%

OPEX defined: 4%

Tariff calculated:

US\$/MMBtu 0.09

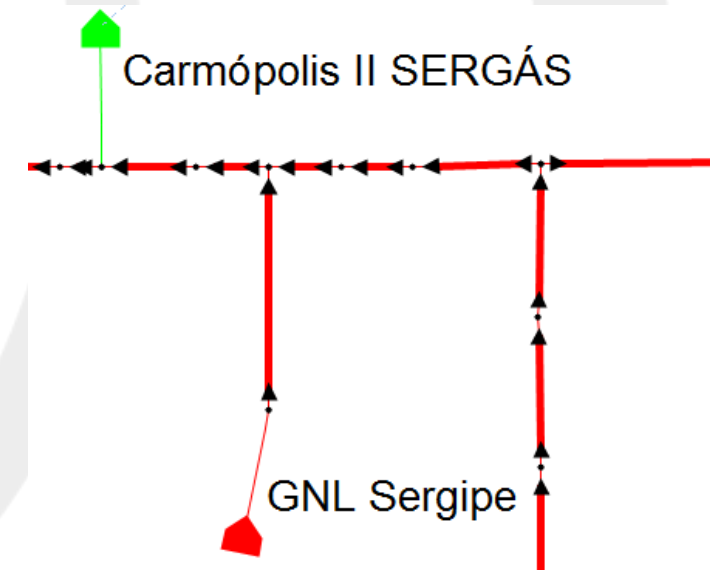
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Source: EPE.

Porto Sergipe – Catu Pilar

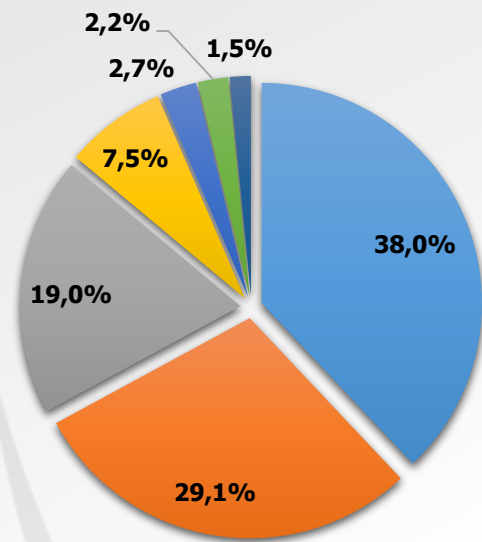
Simulation Results & Discussion

- The zone of influence of the Porto Sergipe terminal would have some congruencies with the Todos os Santos Bay terminal, which could bring some redundancy.
- The Porto Sergipe terminal connection to the gas transmission network could work as a backup supply for the TPP in case of any setback from the FSRU supply.
- Also, according to PDE 2027 data, the Todos os Santos Bay terminal would already have about 70% of its regasification capacity committed in the year 2023.
- Still, there is an expectation of high gas production in the SEAL Basin from 2025 on, which could demand a construction of a new NGPP in the region.
- The proximity between the possible NGPP and the Porto de Sergipe TPP could be a facilitator to build this pipeline.

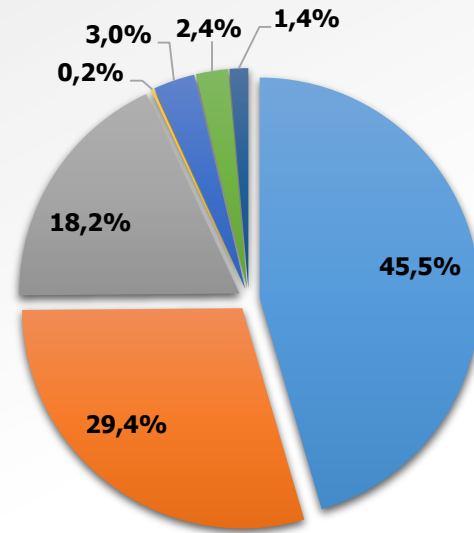


CAPEX Comparison

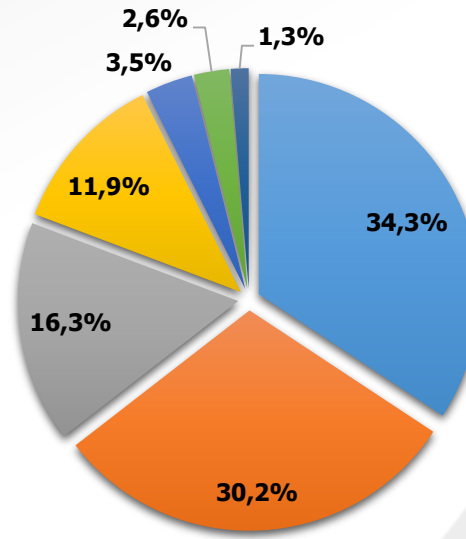
Baumann indicators



Açu-GASCAV



TGS-GASBOL



Porto Sergipe-Catu Pilar



Note: estimates based on concept screening level analyses, with -20% to -50% and +30% to +100% precision.

Source: EPE.

Final Remarks

- The calculated investment costs of the pipelines are consistent with the world standard for pipelines with similar characteristics.
- The amount of gas transported is much more significant on the tariff calculation than the constructive difficulty or the right-of-way annual rental, per example.
- The terminal connection in Southern Brazil could reduce prices, guarantee supply and develop markets.
- Açu Port and Porto do Sergipe terminal if connected to the integrated grid could reduce supply outage risks from TPPs exclusively dependents on FSRUs.
- The construction of these pipelines could compete (or complement) with the existing LNG terminals already connected to the network: same influence area.
- The connection of the terminals to the integrated network in a more open and competitive market could increase flexibility and the operational and commercial safety (increasing the supply portfolio of the transmission company and working as a backup to the natural gas shippers).

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