

Additional Data for “A Novel Framework for Operational Reliability Evaluation of Integrated Electric Power-Gas Networks”

General parameters for natural gas networks:

Parameter	Value
Specific gas constant R	$5.1828 \times 10^{-3} \text{ m}^3 \text{ bar} / \text{kgK}$
Gas temperature T	281.85 K
Gas compressibility Z	0.8
Speed of sound c	380 m/s
Natural gas density ρ_0	$0.68 \text{ kg} / \text{m}^3$
Specific heat ratio γ	1.32
Effective leak area factor ω	0.9

Cross Entropy (CE) Optimization Parameters:

Parameter	Value
Multi-level parameter for cross entropy optimization	0.01
Number of samples for cross entropy optimization	10,000
Maximum number of cross entropy optimization iterations	10

Optimization Parameters

Parameter	Value
Number of linearization points for Weymouth Equation (7-node gas network) per pipeline	20
Number of linearization points for Weymouth Equation (20-node Belgian gas network) per pipeline	60
Number of linearization points for Gas Release Rate Model	5

Data for the 7-node gas network:

Node Data:

Bus	Type	Gas load (factor)	Minimum pressure (bar)	Maximum pressure (bar)
1	Load	0.5	7.23	10.34
2	Load	0.15	9.65	11.72
3	Load	0.35	10.34	13.44
4	Node	0	4.82	6.89
5	Node	0	10.34	13.78
6	Source	0	11.03	16.54
7	Source	0	6.89	9.65

Pipeline Data:

From	To	ψ	In service	Active Pipeline	Compression Factor	Diameter (m)	Length (m)	Friction	MTTF (hour/outage)
2	1	0.03925	1	0	0	0.8	82733	0.01098	1176
2	5	0.02909	1	0	0	0.8	150633	0.01098	1176
6	5	0.03514	1	0	0	0.8	103225	0.01098	1176
5	3	0.03374	1	0	0	0.8	111945	0.01098	1176
7	4	0.03886	1	0	0	0.8	84393	0.01098	1176
4	2	0.03886	1	1	2.5	0.8	84393	0.01098	1764

Gas Generation Data

Node	Maximum Generation (kg/s)	Minimum Generation (kg/s)	MTTF (hour/outage)
6	32.0924	0	1100
7	28.3483	0	950

Gas Storage Data

Node	Maximum Discharge (kg/s)	Maximum Charge (kg/s)	Current SOC (kg)	Minimum SOC (kg)	Maximum SOC (kg)
1	10.6975	10.6975	96277.12	38510.848	192554.24

NGFGs Data

Electrical Bus	Gas Node	Maximum Power	Conversion Factor	MTTF (hour/outage)
1	5	220	0.04033	1100
6	2	20	0.05011	950

Parameters for the 4-state model of Dual-Fuel Natural Gas-Fired Generators (DF-NGFGs)

Parameter	Value
μ_{12}	0.033 transitions/hour
μ_{13}	0.008 transitions/hour
μ_{14}	λ transitions/hour
μ_{21}	0
μ_{23}	0
μ_{24}	2λ
μ_{31}	0
μ_{32}	0
μ_{34}	0.025 transitions/hour
$\mu_{41}, \mu_{42}, \mu_{43}$	0

Where λ is the failure rate of the NGFG.

Data for the 20-node Belgian gas network:

The complete data for this network is available in: D. De Wolf, and Y. Smeers, “The gas transmission problem solved by an extension of the simplex algorithm,” *Management Science*, vol. 46, no. 11, pp. 1454-1465, Nov. 2000.

For the 20-node Belgian Gas Network, the MTTFs of all pipelines are assumed to be 1176 hours/outage. For compressors, the MTTFs are assumed to 1764 hours/outage.

NGFG's Data

Electrical Bus	Gas Node	Maximum Power	Conversion Factor	MTTF (hour/outage)
18	5	400	0.04033	1100
23	13	350	0.05011	1150
21	14	400	0.05011	1100

No changes are made to the test systems' data for the 6-bus power system and the 24-bus IEEE RTS.

For efficiency purposes, natural gas flows on pipelines are scaled down by a factor of 100. Corresponding equations are modified to include this scale factor.