Nomenclature

Symbol	Set	
T	Time periods *t*	
$(nm) \in \Omega^{NGS}$	Natural gas pipelines (*nm*)	
$n, m \in \Omega^{NGS}$	Natural gas nodes (*n*)	
$g \in \Omega^{GS}$	Gas source	
$ic \in \Omega^{IC}$	Interconnection	
$s \in \Omega^{GSD}$	Gas storage	
$(nm) \in \Omega^{LP}$	Pipeline linepack	
Symbol	**Variable description**	**Unit**
ASB	Accumulated system balance	kWh
ASI	Accumulated system imbalance	kWh
ESCB	Estimated system commercial balance	kWh
p_n	Pressures in the pipeline at node *n*	MPa
$p_{ave,nm}^{LP}$	Average absolute gas pressure in the pipeline *nm*	MPa
Q_{nm}	Gas flow in the pipeline *nm*	kWh/h
Q_b^{Bio}	Biomethane injection to the system	kWh/h
Q_{ic}^{Entry}	Entry flow from the neighbouring country	kWh/h
Q_{ic}^{Exit}	Exit flow to a neighbouring country	kWh/h
Q_d^{GD}	Gas demand	kWh/h
Q_{pp}^{GFP}	Consumption of gas of the gas fired power plant	kWh/h
Q_g^{GS}	Gas source flow	kWh/h
$Q_s^{GSD,IR}$	Injection flow to the gas storage	kWh/h
$Q_s^{GSD,WR}$	Withdrawal flow from the gas storage	kWh/h
$Q_{nm}^{LP,IN}$	Inflow of the gas pipeline	kWh/h
$Q_{nm}^{LP,OUT}$	Outflow of the gas pipeline	kWh/h
Q_r^{Rev}	Reverse flow injection from distribution towards transmission system	kWh/h
SL_s^{GSD}	Storage level	kWh
V_{nm}^{LP}	Linepack volume in each pipeline	m^3
Symbol	**Parameter description**	**Unit**
$\eta_{p,nm}$	Efficiency of the pipeline	-
γ_g	Relative density of natural gas	-
C	Constant dependent on system unit	-
C_{nm}	Pipeline parameter	$(m^3/h)/MPa$
C^{LP}	Linepack constant dependent on system unit	-
D_{nm}	Pipeline diameter	mm
f	Friction constant	-
$\underline{GZ}/\overline{GZ}$	Lower and upper green zone limit	kWh
L_{nm}	Pipeline length	km
p_b	Pressure based on normal cubic meter conditions	MPa
p_{ref}	Reference pressure at a node	MPa
$p_m^{min/max}$	Minimum/Maximum operational limits for pressure	MPa
$Q_{ic}^{Entry,\underline{Alloc}/\overline{Alloc}}$	Lower and upper gas flow allocation limits at the entry nodes	kWh/h
$Q_{ic}^{Exit,\underline{Alloc}/\overline{Alloc}}$	Lower and upper gas flow allocation limits at the exit nodes	kWh/h
$Q_{ic}^{Entry/Exit,max}$	Maximum technical capacity for entry/exit from/to neighbouring country	kWh/h
$\underline{Q_d^{GDratio}}/\overline{Q_d^{GDratio}}$	Lower and upper ratio for allocation of every consumption node towards distribution system	kWh/h
$Q_g^{GS,\underline{Alloc}/\overline{Alloc}}$	Lower and upper gas flow allocation limits at the gas source	kWh/h
$Q_g^{GS,min/max}$	Minimum/maximum technical capacity of the gas source	kWh/h
$Q_{s,t}^{GSD,IR,\underline{Alloc}/\overline{Alloc}}$	Lower and upper gas injection rate allocation limits for the gas storages	kWh/h
$Q_{s,t}^{GSD,WR,\underline{Alloc}/\overline{Alloc}}$	Lower and upper gas withdrawal rate allocation limits for the gas storages	kWh/h
$Q_s^{GSD,IR/WR,\min/max}$	Minimum/maximum gas storage injection/withdrawal rates	kWh/h
$Q_t^{JEZ\ Exit,\underline{Alloc}/\overline{Alloc}}$	Lower and upper gas flow allocation limits for the joint exit zone (demand)	kWh/h
$SL_s^{GSD,initial}$	Initial state of energy in the gas storage	kWh
$SL_s^{GSD,min/max}$	Minimum/maximum storage capacity	kWh
T_a	Average absolute gas temperature	K
T_b	Temperature based on normal cubic meter conditions	K
Z_a	Average compressibility factor	-