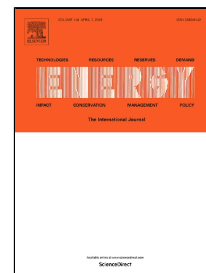


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1 Optimal retrofitting of natural gas pressure reduction stations for energy recovery

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9 *keywords:* natural gas pressure reduction stations; energy recovery; optimal design; system thermal integration; turbo
10 expander; district heating

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12 *Highlights*

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- 14 • A novel comprehensive approach for pressure reduction stations retrofitting based on structured procedure.
- 15 • An optimization model enabling the maximum energy recovery in natural gas pressure reduction stations.
- 16 • Turbo-expander size defining the recovery potential and leading to non-smooth constrained optimization.
- 17 • Optimal design of natural gas expansion process for thermal integration with low-temperature processes.

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20 **Abstract**

21 In this paper, a structured retrofitting approach (SRA) to the near-optimal design of natural gas (NG)
22 pressure reduction stations (PRSs) is presented. The SRA is designed by considering the waste energy
23 recovery, system integration opportunities and long-term-based objectives to successfully address the
24 entire PRS retrofitting process. The SRA is developed in four phases: pre-retrofit activities, preliminary and
25 executive project design, implementation and commissioning and post-retrofit activities. For design
26 optimization during the preliminary and executive project design phase, a novel mathematical model was
27 developed based on the minimization of the levelized cost of energy (LCOE). The optimization model
28 consists of a non-smooth constrained problem that has been solved by means of different solution
29 methods and has been tested for different thermal peak loads, fuel purchase costs, and natural gas flow
30 rates. Variations of the thermal design conditions from 2,900 kW to 1,300 kW for a constant annual heat
31 demand, fluctuations of the percentage increase of the NG cost by 80-100-120-140%, and reductions of the
32 NG user demand of 30% and 60% were considered. The results highlighted that the proposed optimization
33 technique in PRS retrofitting identifies the best system configuration and turbo expander technology.

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