Bilevel Optimization Models for Flow Commitment Contracts in Gas Transmission Planning

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Abstract: Natural gas is transported through large networks of pipelines, where compressors are used to counter the friction-induced pressure loss and gas flow can be controlled with valves.

The transmission system operator (TSO) does not own gas, but provides the transportation as a service to shippers and consumers. These can book capacity from the TSO, in the form of rights to put in gas at entry nodes or take out gas at exit nodes. The validation of a set of bookings involves finding feasible configurations of the network elements for a large set of supply and demand situations. With a model of stationary gas flow, this leads to nonconvex MINLP models. These need to be solved by global solvers in order to decide infeasibilty, i.e., to prove that the network does not provide sufficient transport capacity.

One way to deal with these technical congestions in the network is to increase the capacity by installing new pipelines or compressors. Another way is the use of so-called flow commitment contracts, that allow the TSO to redistribute the supply among the entry points. This increases the flexibility of the TSO as gas flow can be rerouted to avoid known bottlenecks.

The suppliers also take part in the decision process that we formulate as a Stackelberg game with the TSO as leader and the suppliers as a single follower. We model this game as a Bilevel Optimization Problem that extends the MINLP models for gas transport. In the context of real-world data, we investigate the impact of flow commitments on transport capacity.

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