Adding flexibility in a natural gas transportation network using interruptible transportation services

Kjetil T. Midthun, SINTEF Technology and Society
Marte Fodstad, SINTEF Energy Research
Asgeir Tomasgard, NTNU and SINTEF Technology and Society

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Outline

- Motivation
- Model description
- Data
- Results
Motivation

- Increase the total throughput in a natural gas transportation system while maintaining a high level of security of supply

- The TSO (Transportation System Operator) sells firm transportation capacity, but meets uncertainty when operating the system
  - Trade-off between capacity utilization and security-of-supply

- Uncertainties
  - Network capacities due to events (outages, etc)
  - Demand pattern

- Flexibility available to the TSO
  - Rerouting
  - Turn-up
  - Storage in pipelines
Definitions

- **Booking points** are points in the network where producers (=shippers) need to buy transportation capacity to send gas through.

- **Firm** contracts give transportation capacity with a certain level of security-of-supply.

- **Interruptible** contracts give transportation capacity that the TSO can freely interrupt (not deliver):
  - Interruption is not compensated.
  - Tariff is 50% of firm contract tariff.
  - The TSO will prioritize the firm capacity.
  - The TSO will minimize the required interruption in the system.
Model assumptions

- Both the shipper and the TSO has the same insight in the likelihood for events in the system
- The shipper does not have insight in the network topology except for the booking points
- The TSO does not have insight in production cost functions and gas market prices
- We aggregate all shippers to one decision maker
  - This avoids a game situation between the shippers
- Uncertain prices in the downstream gas markets
  - No price elasticity
  - No contracted sales
1. The shipper nominates firm capacity
2. The TSO allocates firm capacity
3. The shipper books interruptible capacity
4. The TSO observes events and decides upon flow and interruptions in the network
5. The shipper produces and sells gas

- The shipper does not recognise the availability of interruptible contracts as firm contracts are nominated
- Simulates firm contract priority
- The shipper does not consider the security of supply requirement when nominating firm capacity

**Decision sequence**
Connection between the models
Topology
Production cost

- Gas-to-oil ratios from Facts 2011
- Swing production cost from Kon-Kraft 2003 and Golombek et al. 1998
Gas price scenarios

- Mean, variance, skewness, kurtosis and correlations from 2010/2011 prices in NBP, Zeebrugge, GasPool and NetConnect
- Dunkerque price: 10% GasPool and 90% Zeebrugge
Events

- Synthetic data
- Individual events only
- An event causes capacity reduction
- Events in fields, landing points and the processing plants Kollsnes and Kårstø
- The probabilities are calibrated such that the availability corresponds to the average availability figures reported by Gassco (annual reports)

<table>
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<th>Scenario</th>
<th>Node</th>
<th>Prob</th>
<th>Cap reduction</th>
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<tr>
<td>19</td>
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Tests

• Comparison with a benchmark
  • No interruptible booking

• Sensitivity:
  • Different requirements for the security-of-supply level for the firm capacity
Expected throughput

- 25-250% increased throughput compared to the benchmark
- Similar pattern for income, 13-274% increase
Total booking

- Unbalanced booking is valueable, books (and pays) for 90 MSm\(^3\) additional entry capacity
- Reduced firm booking without interruptible is due to the balance requirement
Production cost

- The steep part of the realized production cost comes from lost oil income
Different objectives

• TSO objective
  • Firm allocation: Min square deviation from firm nomination
  • Interruption and routing: Min tariff-weighted square interruption
• Producer objective: Max expected profit

• Lack mechanism to align the objectives
  • TSO might e.g. give priority to swing production rather than must-take production

• Tested alternative TSO models
  • Objective: Max social surplus (=producer surplus)
  • Allow interruption to exceed minimum interruptible level if that is most profitable
Profit increase with alternative TSO modelling
Conclusion

• The flexibility inherent in interruptible contracts can improve the utilization of a gas network with events
  • Security-of-supply requirements for firm contracts crucial for the size of this improvement

• The ability to book unbalanced (entry vs exit) can be valueable

• System "loss" can be experienced if producer and TSO have incoherent objectives
  • Design of TSO allocation principles and possibility for producers to send priority signals influences system performance