Optimizing the Offshore Pipeline System for Natural Gas in the North Sea

Recent extensions of the GassOpt model

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Outline

- Introduction to GassOpt
  - StatoilHydro and Gassco’s motivation
- The basics of the model
  - New properties
- Benefit and Value creation
- Conclusion
Technology position for stakeholders in the capacity assessment process:

A complete Gas Value Chain approach

- StatoilHydro and Gassco are the users of the GassOpt model
- The NCS gas value chain includes:
  - 7800 km of large diameter pipelines
  - Riser platforms
  - Processing plants
  - Receiving terminals located in four European countries
  - An integrated system attached to major gas fields and large downstream distribution systems
- Key elements to secure success in operating the NG value chain includes:
  - Portfolio Perspective
  - Gas Quality Management
  - Flexibility and market requirements
  - System robustness and integrity
  - Security of Supply

A well driven gas value chain integrates optimally with oil producing fields where NG is a bi-product

Transport capacity: ~348 mscm/d
(~75% shipped by StatoilHydro)
Decision making:

The basic planning problem

- Network with ~100 Nodes and ~100 Arcs
- Fields with different gas composition
  - Production profiles
  - 12 components
- Exit points with different gas quality requirements
  - Demand profiles
- Physics of flow
- Bottlenecks / processing properties
  - Interrelations between pipelines and different routing options influence the flow capacity

- What is the throughput capacity for a given state of the network, and different production scenarios?
Flow and pressure

\[ Q = k \cdot \left( p_{\text{in}}^2 - p_{\text{out}}^2 \right)^\alpha \]
Gas quality

- Natural gas heterogeneous commodity (12)
  - Hydrocarbons (9)
    - Methane
    - Ethane
    - ...
    - C_{7}+ (Aggregated)
  - Nitrogen (1)
  - Restrictions regarding contaminants (2)
    - CO_{2}
    - H_{2}S

- Exit points are contractually restricted by GCV, WI
  - SI (soot index) and ICF (incomplete combustion factor)
System effects

- What you do in one part of the network may influence operations in other places
- Caused by pressure/flow relationship and blending/pooling
System effects - pressure

Total flow: 68.16
System effects - quality

A \(\text{CO}_2=1\%\) \(f=10\) \(\rightarrow\) C

B \(\text{CO}_2=10\%\) \(f=10\) \(\rightarrow\) C

C \(f=10\) \(\rightarrow\) D \(\text{CO}_2=5.5\%\)

C \(f=10\) \(\rightarrow\) E \(\text{CO}_2=5.5\%\)
Gas quality – the calculation time challenger:

Discretization of pooling

Correct gas split in components
- Implemented with S1 sets
- Focus in ongoing research project - parallelization
Recent extensions in GassOpt

- Increased importance of gas quality impact on capacity
  - Larger variations
  - Higher CO₂ contents
  - Quality demand at exit points (WI)

- Increased focus on energy-efficient operation (and environmental emissions)
  - Compressor stations in the system increases system flexibility,
  - but, they are energy intensive
Processing plants

- From Rich to Dry gas
  - Quality
  - Mass balance
  - CO₂ removal
  - Heavy hydrocarbons removal (and water)
  - Storage tanks
  - Value of the removed components
  - Varying component offtake

Kårstø Processing Plant, Norway
Technology and Society
Compressor with recycle flow

Binary split
Varying component offtake/removal

Cross over leg
New and improved compressor station modelling

- Throughput limitations
- Power consumption
- Binary split
- Recycling
- Compressor combination alternatives (several compressors in a station)
- Crossover opportunities
- Include thermodynamic properties, such as temperature, compressibility facto, kappa

Compressor power,\[ P = \frac{p_{\text{std}} Z_{\text{in}} T_{\text{in}} \kappa}{\eta_{\text{in}} \eta_{\text{sec}} T_{\text{std}} (\kappa - 1)} \times Q \times \left( \frac{p_{\text{out}}}{p_{\text{in}}} \right)^{\kappa-1} \times \frac{1}{24 \times 3600} \]

GassOpt: Benefit and value creation

- GassOpt has helped creating considerable values from 1995 up until today
  - Reduced losses during temporary production shutdowns
  - Prevent investment decisions shown to have a significant negative effect on other promising field development options.
  - Increased precision in transport capacity booking
  - Avoiding decisions which would have reduced oil production
  - Increased precision in field development decisions
  - Increased the ability to deliver Gas with right quality
Concluding Remarks

- GassOpt has been an important factor in utilization and development of NCS pipeline system
- GassOpt has helped StatoilHydro create considerable values in the last decade
- The new properties regarding process and compressor modeling will further increase the ability to
  - Make excellent investments decisions
  - Estimate security of supply and utilize the flexibility in the network
Additional spin-offs from the GassOpt project

- **VENOGA (R&D 2001-2005 - Released 2007)**
  - Valuation of flexibility
  - Spot vs. physical deliveries
  - Stochastic optimization – multi-period model

- **SING - SUPPLY (release April 2008)**
  - Daily lifting decisions – multi-period model
  - Risk aversion

  - R&D project
  - Refined versions of GassOpt

- **LNG Shipping (2008-2011)**
  - R&D: Global NG business optimization
  - Link pipeline based NG activity to LNG

- **Gassopt Advanced (2008-2010)**
  - Short term optimization
  - Parallelization