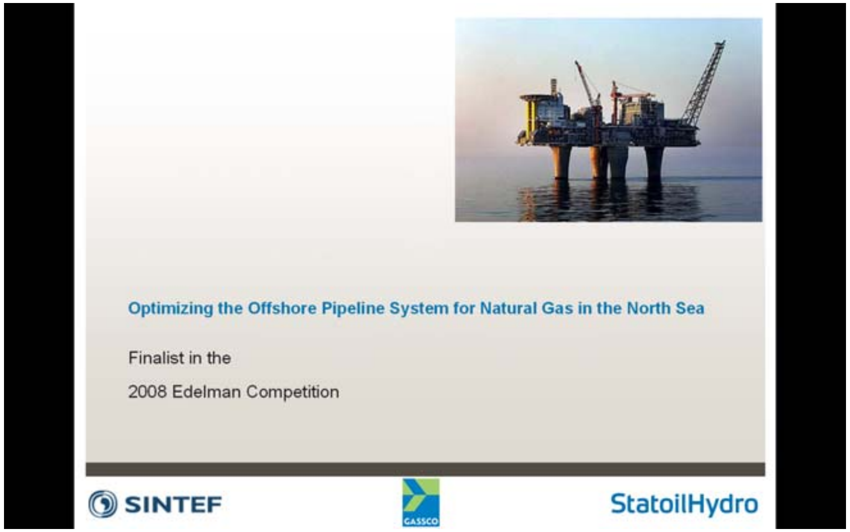
1st Trondheim Gas Technology Conference - 2009 :

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

Recent extensions of the GassOpt model

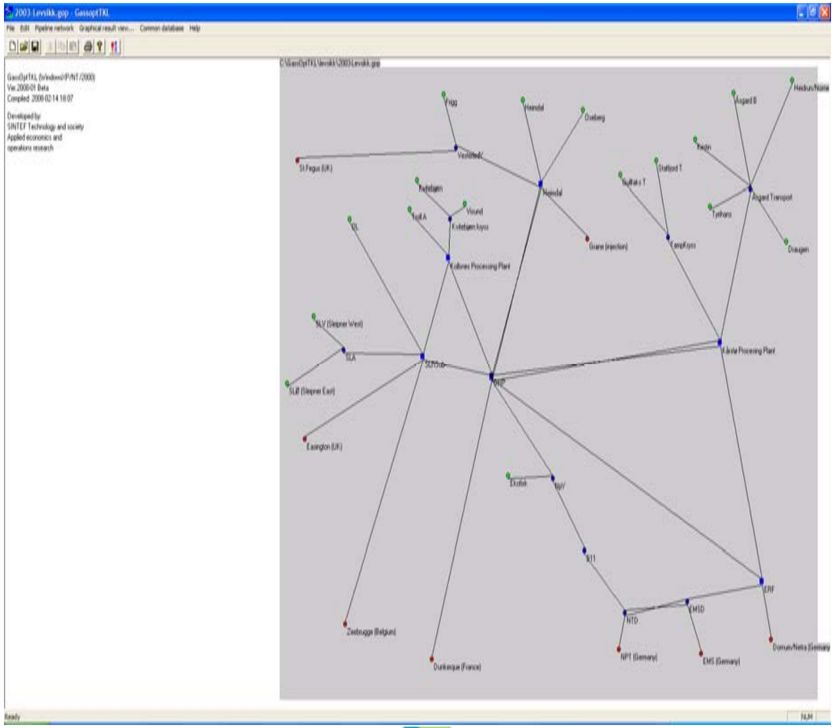


Vibeke Nørstebø
Frode Rømo
Lars Hellemo
Marte Fodstad

SINTEF Technology and society
Applied economics and operations research

Outline

- Introduction to GassOpt
  - StatoilHydro and Gassco's motivation
- The basics of the model
  - New properties
- Benefit and Value creation
- Conclusion



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

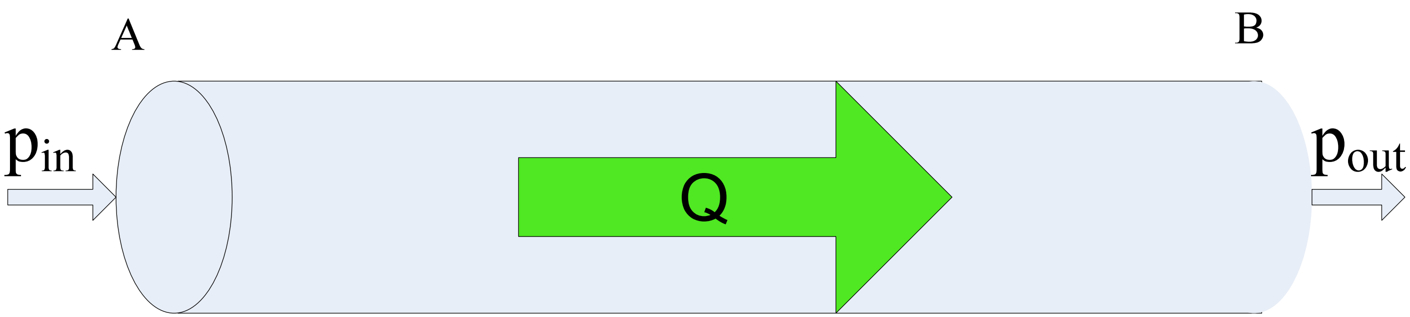
Decision making:

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



$$Q = k \cdot \left(p_{in}^{2} - p_{out}^{2}\right)^{\alpha}$$

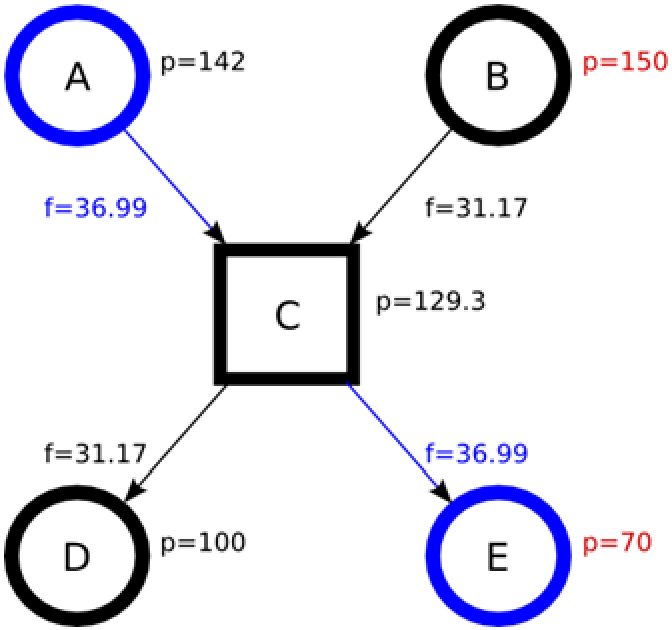
Gas quality

- Natural gas heterogeneous commodity (12)
  - Hydrocarbons (9)
    - Methane
    - Ethane
    - …
    - C_7+ (Aggregated)
  - Nitrogen (1)
  - Restrictions regarding contaminants (2)
    - CO_2
    - H_2S
- Exit points are contractually restricted by GCV, WI
  - SI (soot index) and ICF (incomplete combustion factor)

System effects

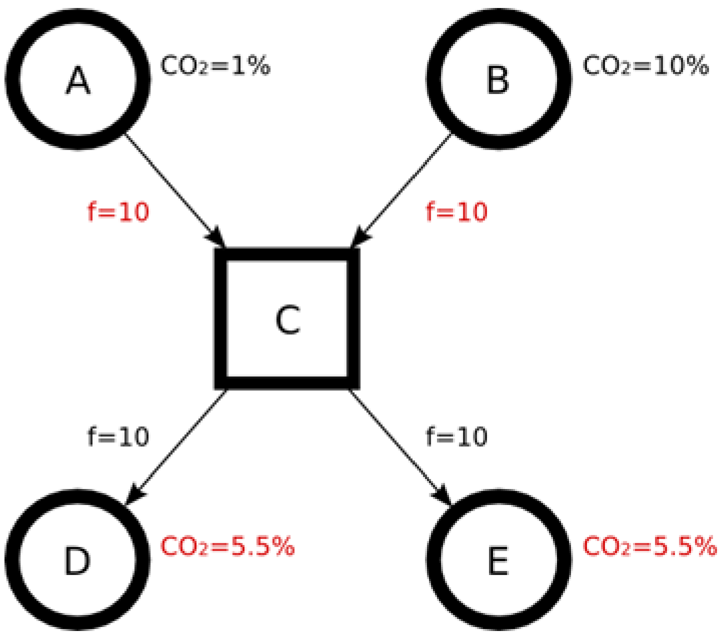
- What you do in one part of the network may influence operations in other places
- Caused by pressure/flow relationship and blending/pooling

System effects - pressure



Total flow: 68.16

System effects - quality

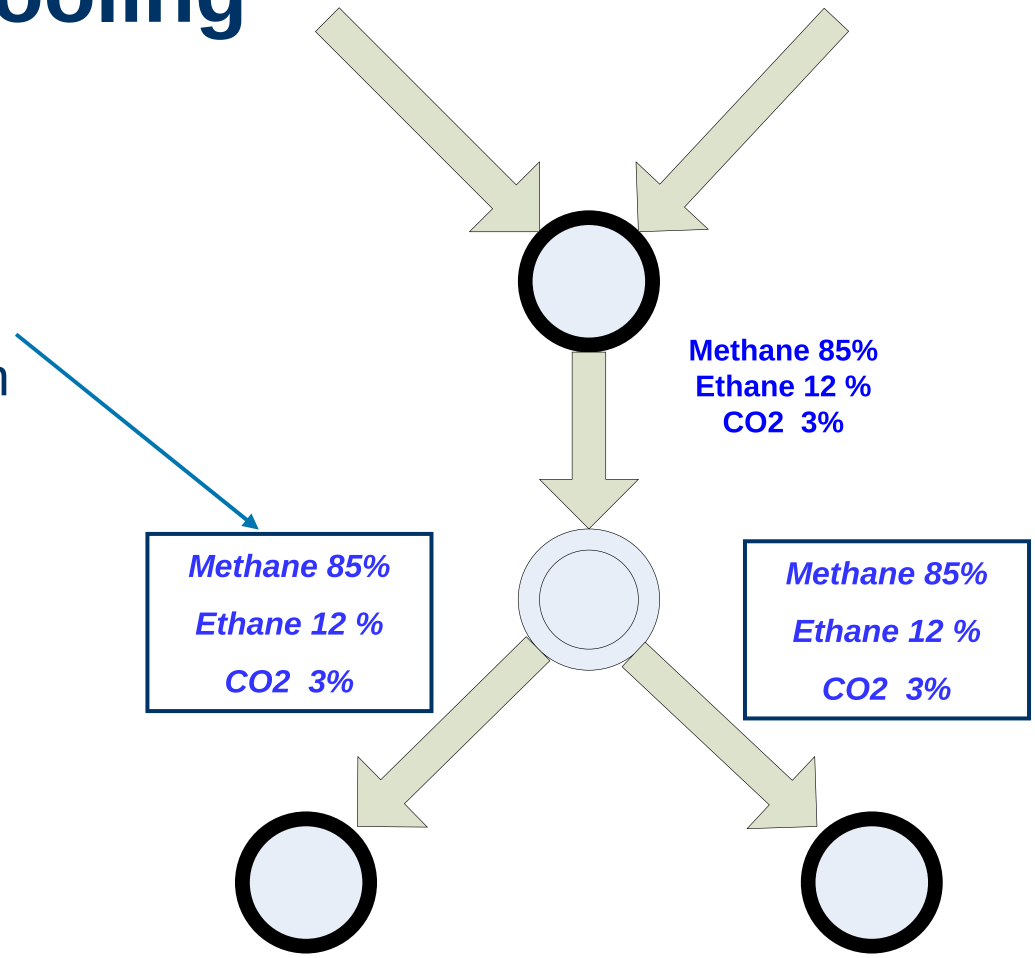


Gas quality – the calculation time challenger:

Discretization of pooling

Correct gas split in components

- Implemented with S1 sets
- Focus in ongoing research project - parallelization



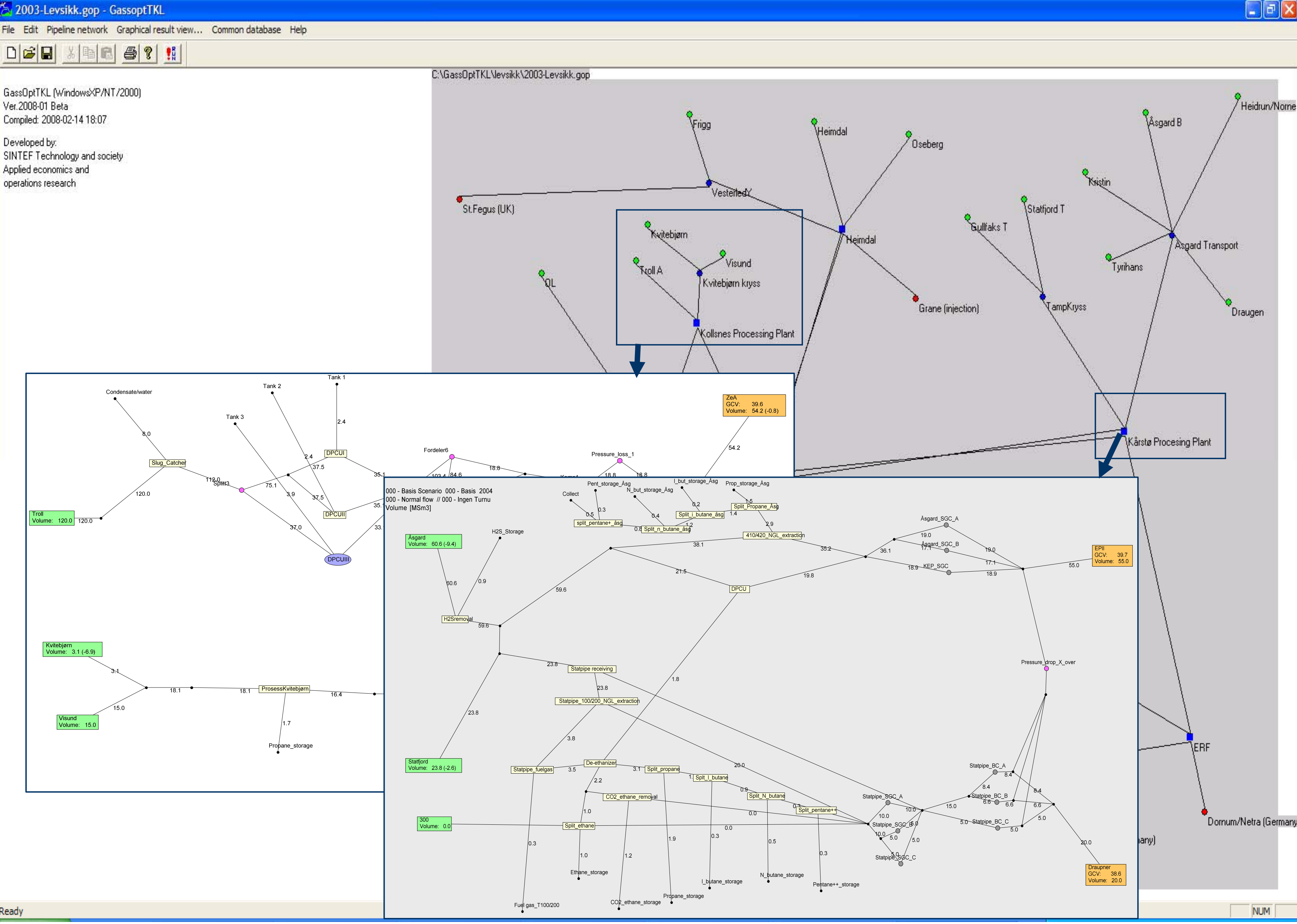
Recent extensions in GassOpt

- Increased importance of gas quality impact on capacity
  - Larger variations
  - Higher CO_2 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

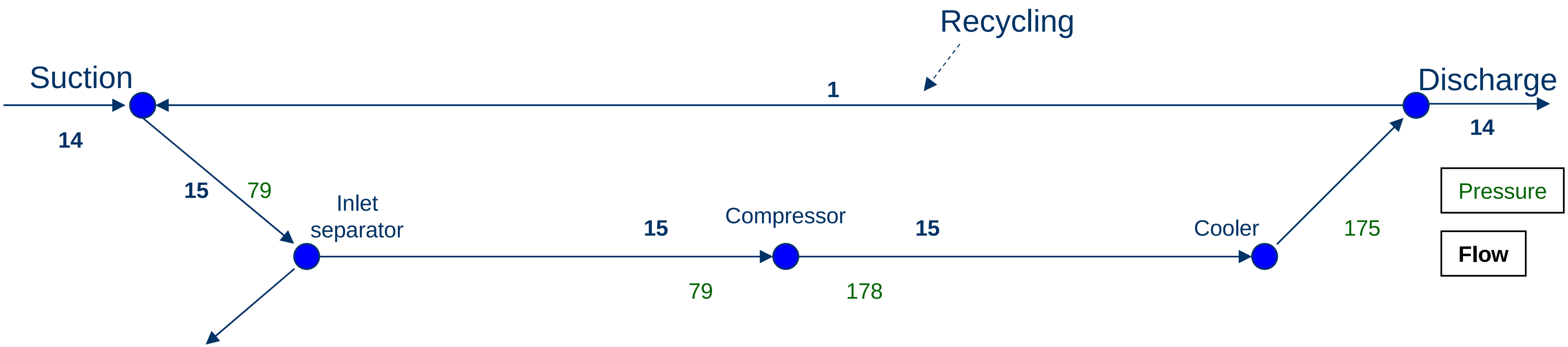
Processing plants

- From Rich to Dry gas
  - Quality
  - Mass balance
  - CO_2 removal
  - Heavy hydrocarbons removal (and water)
  - Storage tanks
  - Value of the removed components
  - Varying component offtake

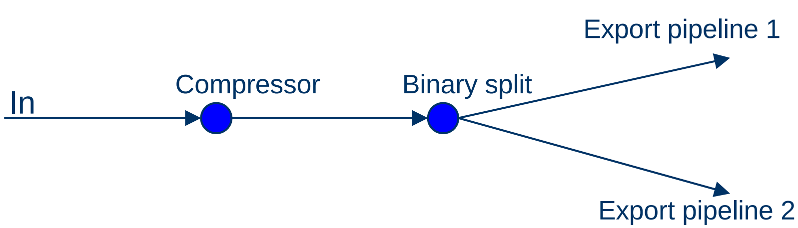
Kårstø Processing Plant, Norway


2003-Levsikk.gop - GassoptTKL
File Edit Pipeline network Graphical result view... Common database Help
C:\GassOptTKL\levsikk\2003-Levsikk.gop
GassOptTKL (WindowsXP/NT/2000)
Ver.2008-01 Beta
Compiled: 2008-02-14 18:07
Developed by:
SINTEF Technology and society
Applied economics and
operations research
Frigg
Heimdal
Oseberg
Åsgard B
Heidrun/Norne
Kristin
St.Fegus (UK)
VesterledY
Heimdal
Statfjord T
Gullfaks T
Åsgard Transport
Kvitebjørn
Visund
Troll A
Kvitebjørn kryss
Tyrihans
OL
Grane (injection)
TampKryss
Draugen
Kollsnes Processing Plant
Kårstø Procesing Plant
ERF
Dornum/Netra (Germany)
Condensate/water
Tank 1
Tank 2
Tank 3
Slug_Catcher
DPCUI
DPCUII
DPCUIII
Fordeler6
Pressure_loss_1
ZeA
GCV: 39.6
Volume: 54.2 (-0.8)
Troll
Volume: 120.0
Kvitebjørn
Volume: 3.1 (-6.9)
Visund
Volume: 15.0
ProsessKvitebjørn
Propane_storage
000 - Basis Scenario 000 - Basis 2004
000 - Normal flow // 000 - Ingen Turnu
Volume [MSm3]
Asgard
Volume: 60.6 (-9.4)
H2S_Storage
H2Sremoval
Pent_storage_Åsg
N_but_storage_Åsg
I_but_storage_Åsg
Prop_storage_Åsg
Collect
split_pentane+_åsg
Split_n_butane_åsg
Split_i_butane_åsg
Split_Propane_Åsg
410/420_NGL_extraction
Åsgard_SGC_A
Åsgard_SGC_B
KEP_SGC
EPII
GCV: 39.7
Volume: 55.0
DPCU
Statpipe receiving
Statpipe_100/200_NGL_extraction
Pressure_drop_X_over
Statfjord
Volume: 23.8 (-2.6)
Statpipe_fuelgas
De-ethanizer
Split_propane
Split_I_butane
CO2_ethane_removal
Split_N_butane
Split_pentane++
Split_ethane
300
Volume: 0.0
Statpipe_BC_A
Statpipe_BC_B
Statpipe_BC_C
Statpipe_SGC_A
Statpipe_SGC_B
Statpipe_SGC_C
Draupner
GCV: 38.6
Volume: 20.0
Ethane_storage
I_butane_storage
N_butane_storage
Pentane++_storage
Propane_storage
CO2_ethane_storage
Fuel gas_T100/200
Ready
NUM

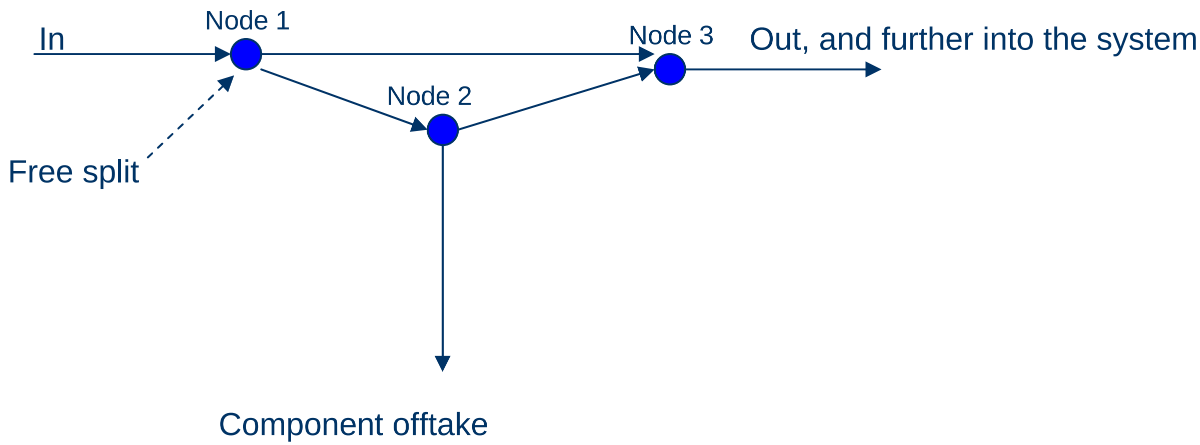
Compressor with recycle flow



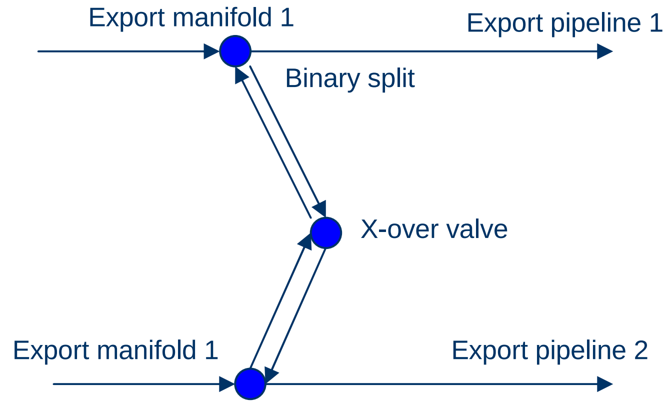
Binary split



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

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

- Linearisation, Tom van Hoeven (2004)

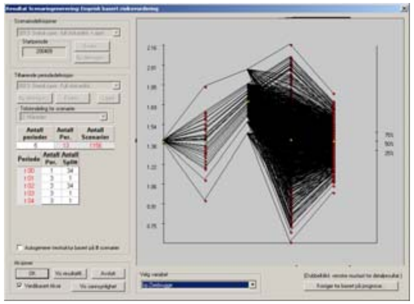
GassOpt: Benefit and value creation

- 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
- Ramona (2006-2011)
  - 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

Arctic Discoverer at Cove Point, MD