Assessment of allocation systems

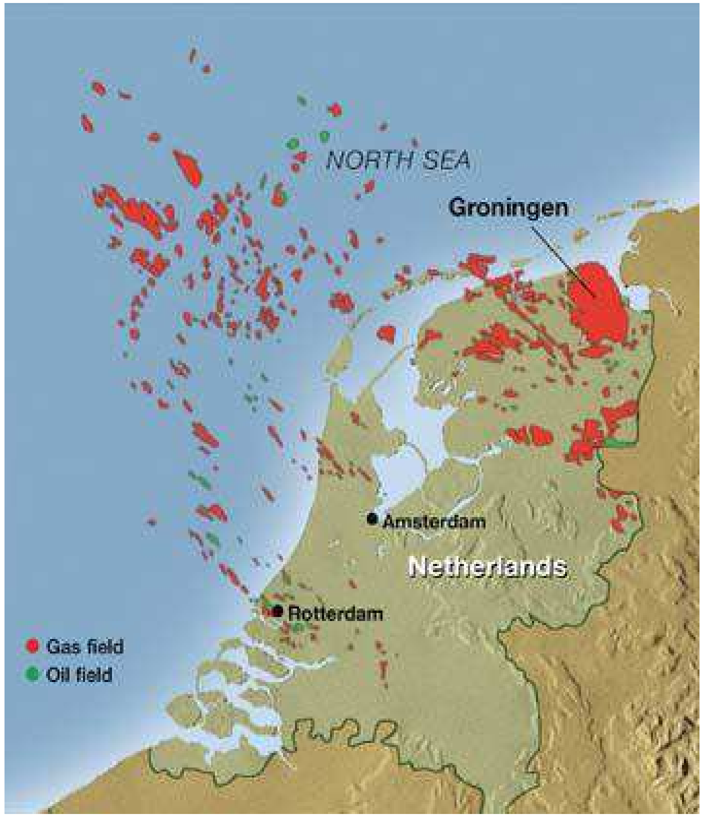
New approach combining DVR and PVT simulations

Dennis van Putten, Lennart van Luijk, Henk Riezebos

27 June 2019

Our Groningen (the Netherlands) Heritage in natural gas

Gas Fields	Netherlands

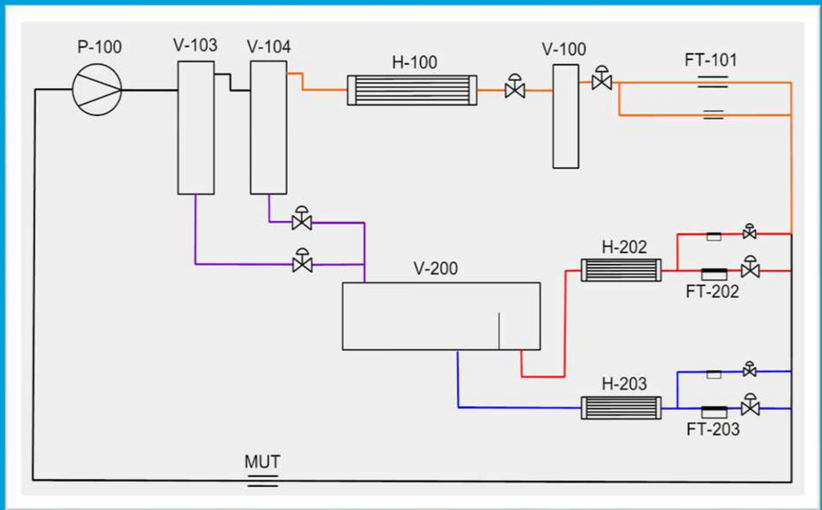


1959	First Gas Discoveries
Discovery of the huge Groningen gas field	
1963	Integrated Gas Company
Foundation of the integrated gas company	Gasunie
2005-2009	Unbundling
▪ Gas Trading Company ▪ Gas Transport Company ▪ Gas Consulting & Services	GasTerra gasunie KEMA
2012	Acquisition
KEMA was acquired by DNV	DNV KEMA
2013	Merger
DNV merged with GL	DNV·GL

Historic background of laboratory achieved knowledge

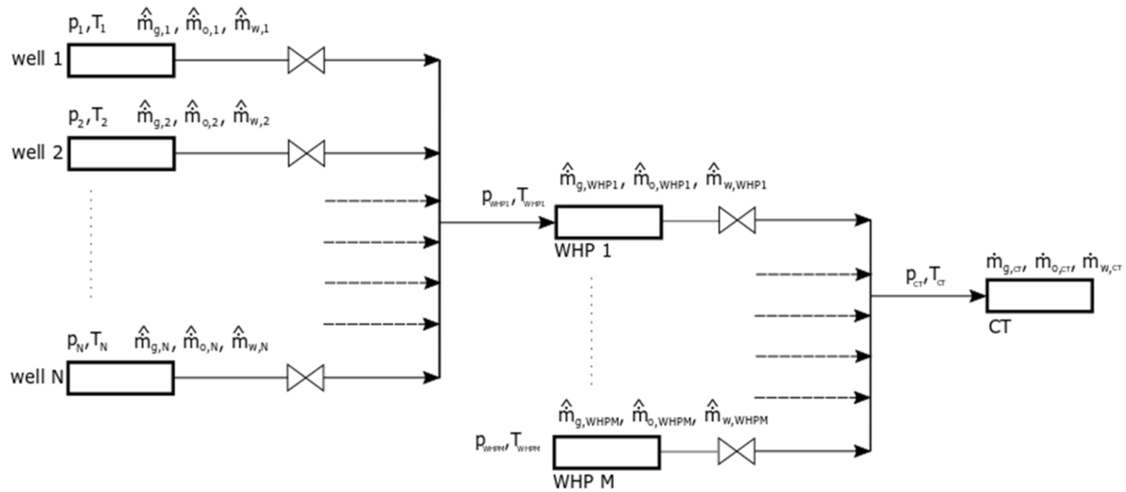
Timeline:

- 1973 – 1978 gas labs built by Gasunie
- 1978 Westerbork facility opened
- 1978 1st FLOMEKO in Groningen
- 2003 xth FLOMEKO in Groningen
- 2013 MPFLG Multiphase Flow lab Groningen



Allocation systems help to compensate for measurement uncertainty/ errors

- In oil & gas production accurate measurements are required, yet not always achievable (oil,water,gas) combination
- Imbalances in the measurement systems need to be compensated by allocation methods
- Increased complexity in production systems require more adequate and fair allocation methods than currently present (by-difference, pro-rata, uncertainty-based):
  - Different technologies lead to different measurement accuracy classes
  - Multi-stage allocation systems
  - Complex phase behaviour from well to Custody Transfer (CT location)
- Use of Data Validation and Reconciliation with proper process simulations can fill this gap



Data Validation & Reconciliation: Method (1)

- Data Validation and Reconciliation (DVR) is a new approach:
  - Aims to minimize the total uncertainty-scaled measurement reconciliation

$$F(\hat{\dot{\mathbf{m}}}_k, \dot{\mathbf{m}}_k, \boldsymbol{\sigma}_k) = \sum_j \left(\frac{\dot{m}_{k,j} - \hat{\dot{m}}_{k,j}}{\sigma_j} \right)^2$$

Minimize cost function

Measured value

Allocated value

Absolute measurement uncertainty

Data Validation & Reconciliation: Method (2)

- Data Validation and Reconciliation (DVR) is a new approach:
  - Aims to minimize the total uncertainty-scaled measurement reconciliation

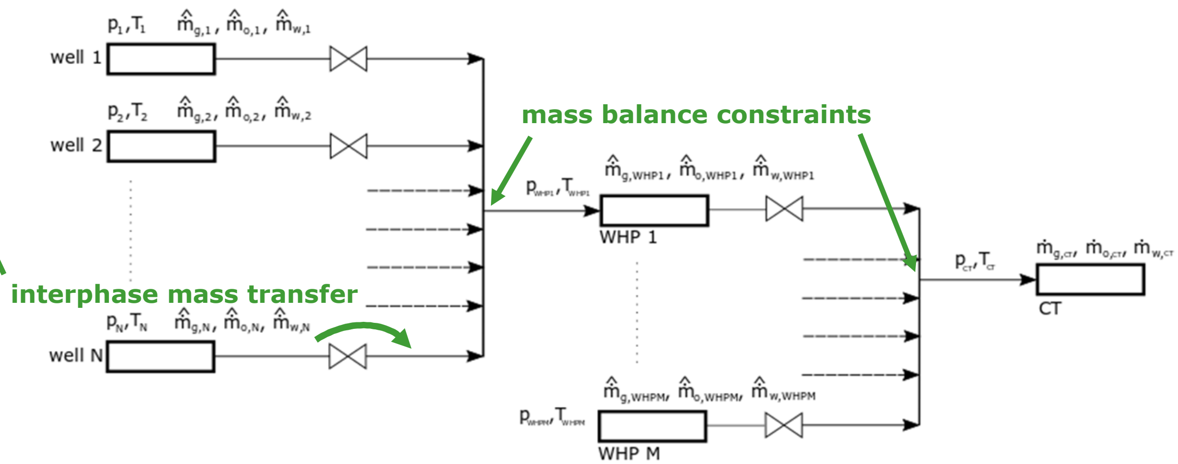
$$F(\hat{\mathbf{\dot{m}}}_k, \mathbf{\dot{m}}_k, \boldsymbol{\sigma}_k) = \sum_j \left(\frac{\dot{m}_{k,j} - \hat{\dot{m}}_{k,j}}{\sigma_j} \right)^2$$

Minimize cost function

  - Subject to mass balances of the allocation system

$$\dot{m}_{k,\mathrm{CT}} = \sum_j f_j \dot{m}_{k,j}$$

Subject to (multiple) mass balance constraints including phase exchange



Data Validation & Reconciliation: PVT and measurement uncertainty

- A process simulation tool (HYSYS) is used to calculate the mass balance of each individual flow
- Phase changes are automatically taken into account in this process model
- Additional advantage is that all PVT data is available at all stages in the allocation system and can be checked with the configuration of the metering systems.

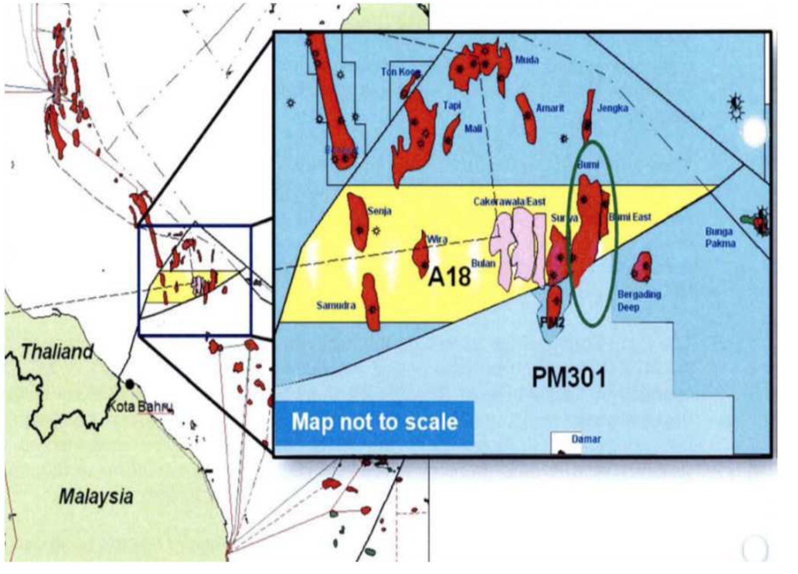
- Measurement uncertainties of each phase measurements needs to be quantified

- Minimization problem with constraints can be solved by the use of Lagrange multipliers and is automated in Matlab

Case study: Carigali Hess wet gas allocation system (1)

- DVR was used to assess large wet gas allocation system in an offshore Malaysia-Thai shallow water area: 12 different fields with over 120 wells, connected to 6 well head platforms (WHP)
- A combined BD and PR allocation systems are currently in place
- Measurements on the wells performed by Venturi meters with a wet gas correction algorithm

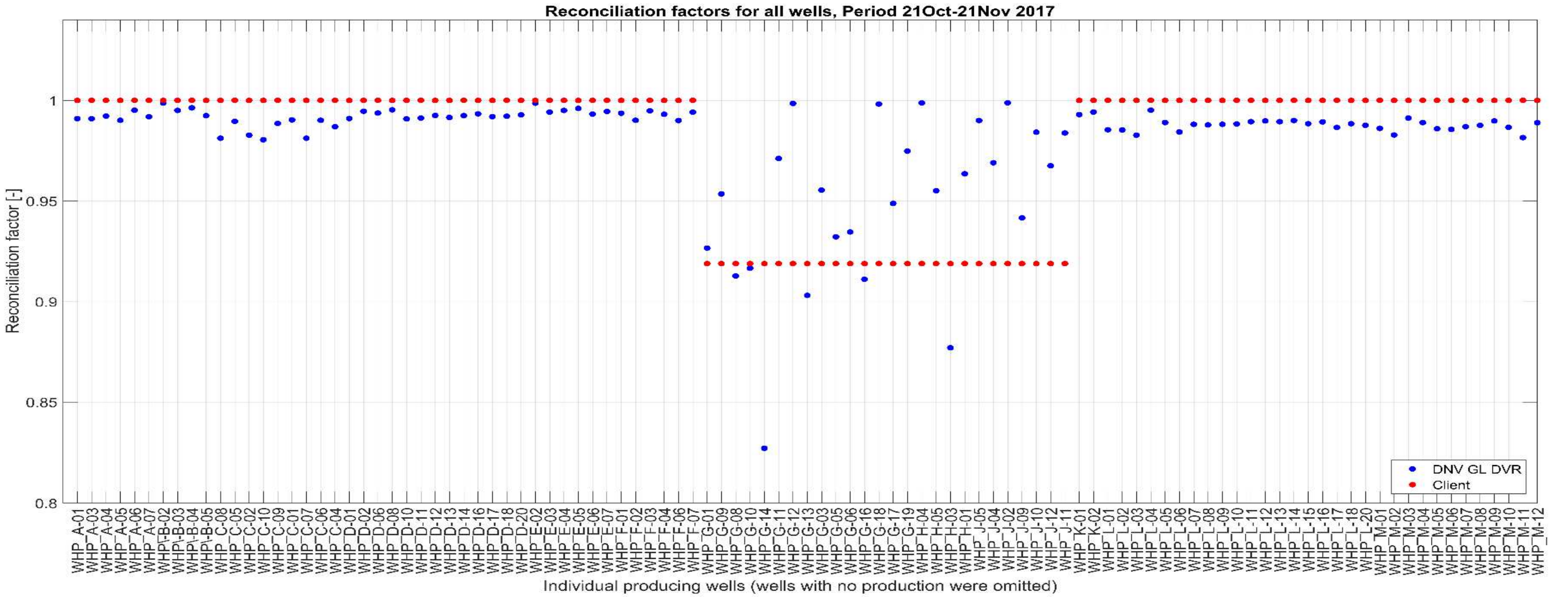
- DVR requires the uncertainty of these measurements and their dependencies:
  - Choice of correction model
  - Calibration uncertainty of the measurements
  - Range of operation
  - Fluid composition
  - Wetness conditions



DNV·GL

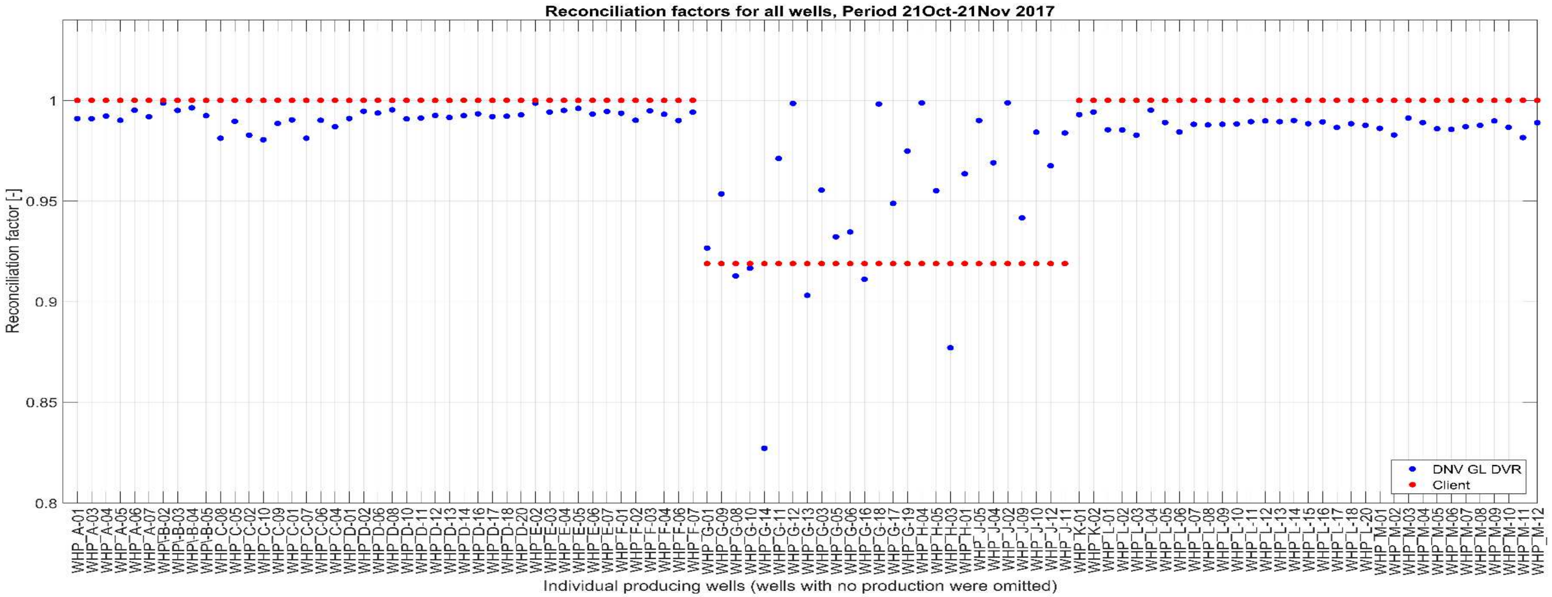
Case study: Carigali Hess wet gas allocation system (2)

- Results of the gas reconciliation factors: current allocation method (red) and DVR method (blue)
- Current allocation method produces a reconciliation factor of 1 for the WHP’s that are unaffected by the BD allocation procedure
- The wells that are corrected all have the same reconciliation factor



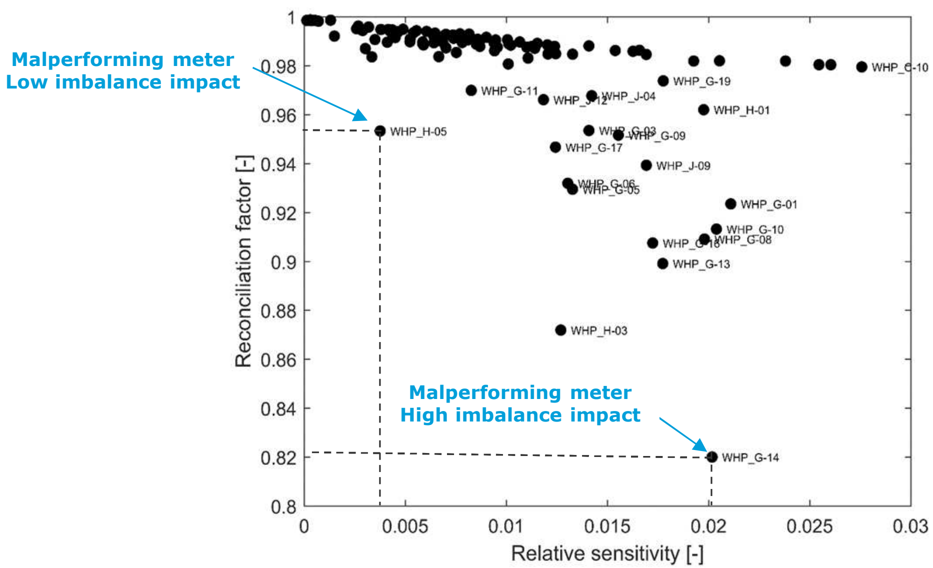
Case study: Carigali Hess wet gas allocation system (3)

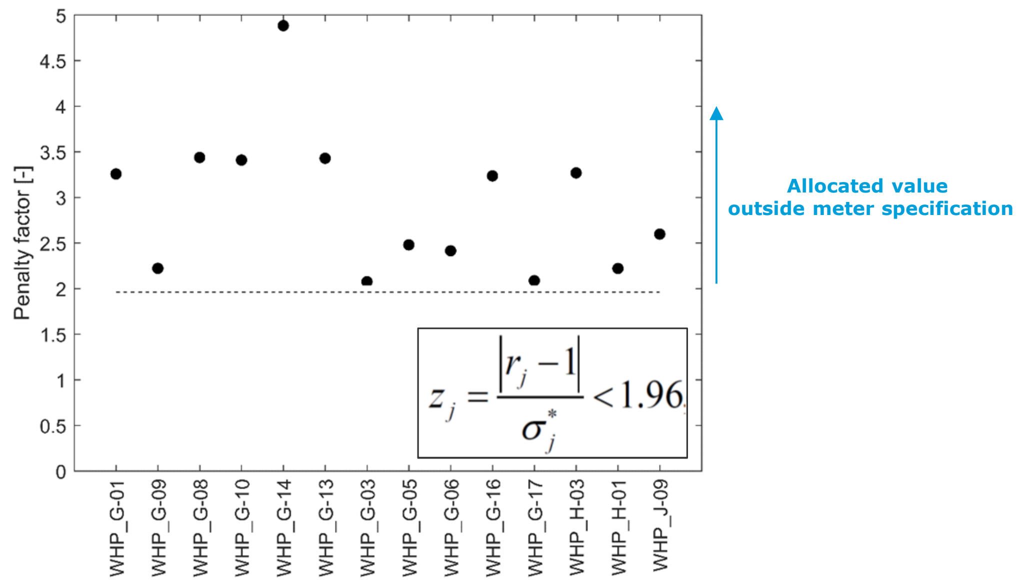
- With DVR the absolute uncertainty of the measurement determines the reconciliation factor
- In general, the wells with high production volumes have a higher reconciliation factor, and therefore more of the imbalance of the allocation system is assigned to these wells
- The sources of uncertainty differ per well (dp-range setting, meter calibration and configuration)



Case study: Carigali Hess wet gas allocation system (4)

- DVR allows for further analysis of the allocation system
  - Most dominant wells in terms of largest impact to allocation imbalance (sensitivity factor)
  - Identify mal-performing meters by means of penalty factor





Conclusion

- DVR is an elegant and statistically more accurate approach, able to tackle more complex allocation challenges than traditional methodologies
- It provides prioritization of the improvements to minimize the imbalance in a production system
- This leads to fairer allocation and hence fairer division of revenues amongst stakeholders

Thank you!

Henk Riezebos
Henk.Riezebos@dnvgl.com

www.dnvgl.com

SAFER, SMARTER, GREENER