NFOGM
NORWEGIAN SOCIETY FOR OIL AND GAS MEASUREMENT

# Uncertainty related to ownership allocation

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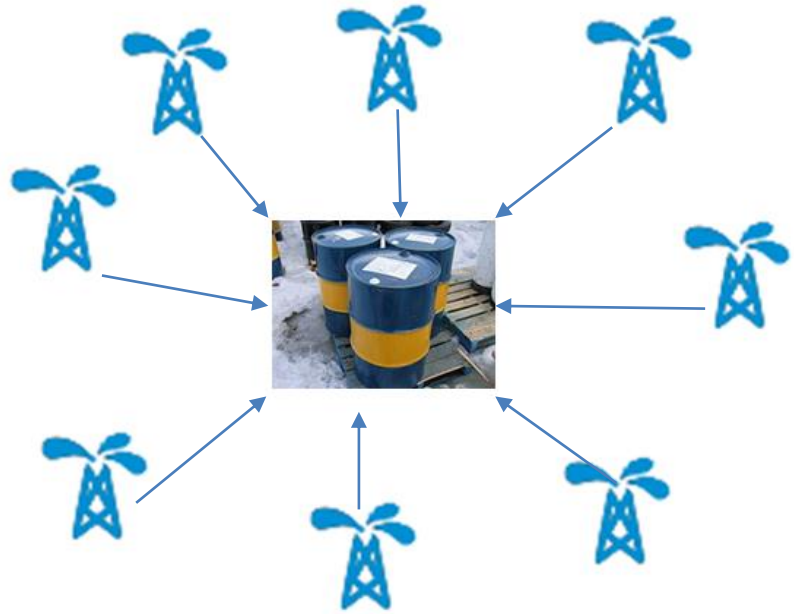
- Field allocation uncertainty
- Ownership allocation uncertainty
- Risk related to ownership allocation
- Comparison to ownership factor
- Summary

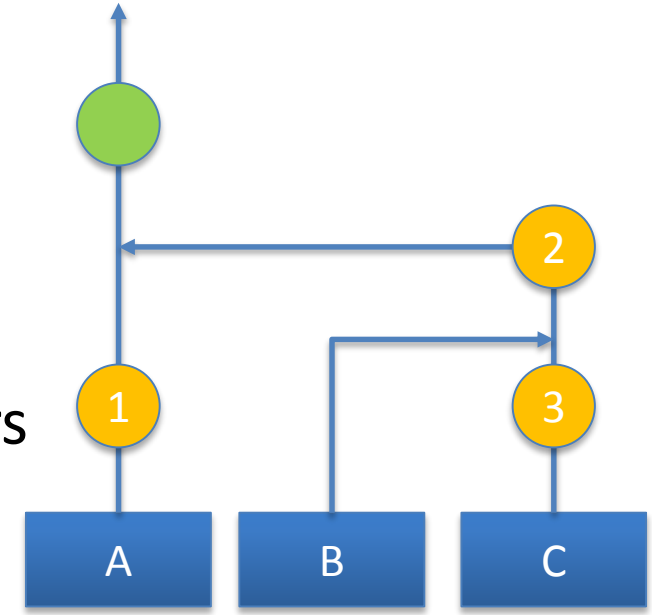
# Introduction

- Increasing attention to uncertainty related to allocation
  - Both field and ownership
- Involve uncertainty calculations at system level
- Straighforward allocation principles, often complex details



# Field allocation uncertainty

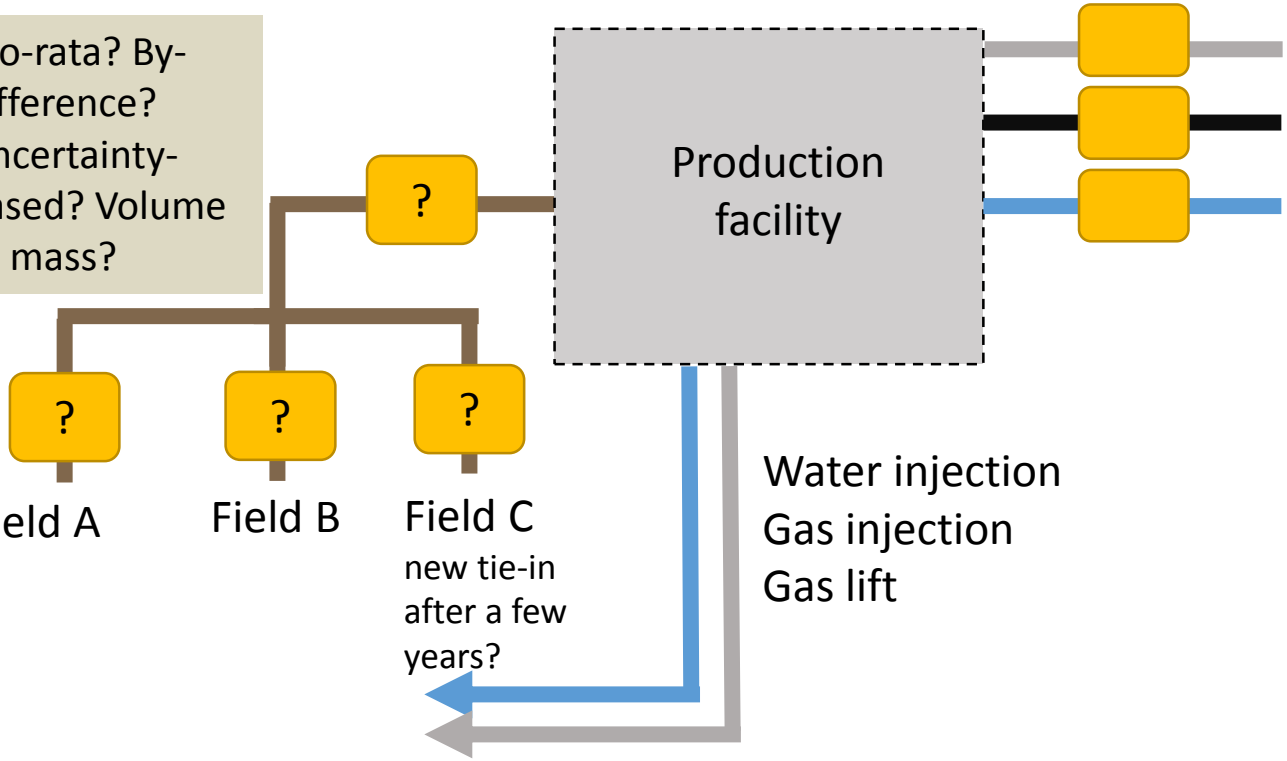
- Affected by
  - Metering station uncertainty
  - Production profile
  - Composition
  - Uncertainty in prosess parameters (P, T, ORF…)
  - System topologi
  - Allocation methodology




- With ISO Gum, NFOGM tools, Energy Institute guideline - > This is possible to do…

# This is possible to do……

Pro-rata? By-difference? Uncertainty-based? Volume or mass?



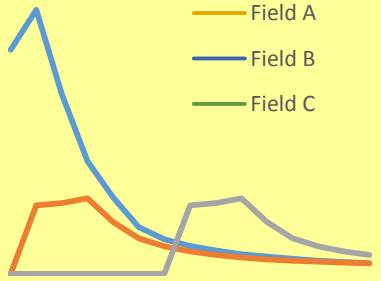

Fragmented ownership

| | Field A | Field B |
|---|---|---|
| Owner 1 | 30 % | 98 % |
| Owner 2 | 60 % | 0 % |
| Owner 3 | 10 % | 2 % |

Component-based allocation?

+ sampling
+ flow rate estimates
+ HYSYS / PVT simulation uncertainties for ORF / Kappa estimation

What about changing rates through field lifetime?



# This is possible to do…

… but it soon gets complicated
solving the allocation equations
analytically or using an excel model

$$M_{x,i}^{HC} = M_{x,i}^{gas} + M_{x,i}^{oil} - M_{x,i}^{gas\ lift} - M_{x,i}^{flare\ gas}$$

$$M_{x,i}^{gas} = M_{x}^{gas} \cdot w_{x,i}^{gas}$$

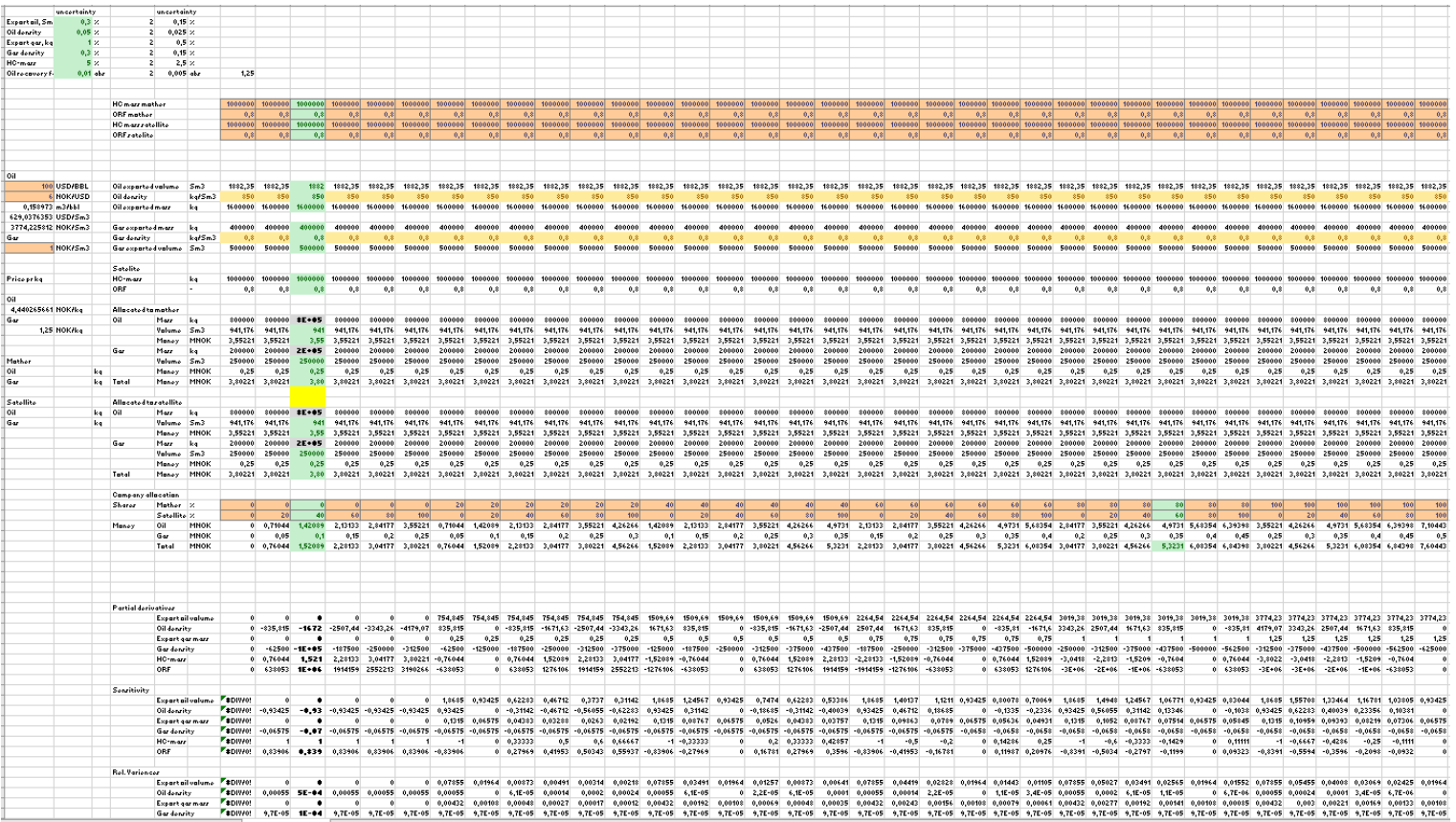
$$M_{x,i}^{oil} = M_{x}^{oil} \cdot w_{x,i}^{oil}$$

$$M_{x,i}^{gas\ lift} = M_{x}^{gas\ lift} \cdot w_{x,i}^{gas\ lift}$$

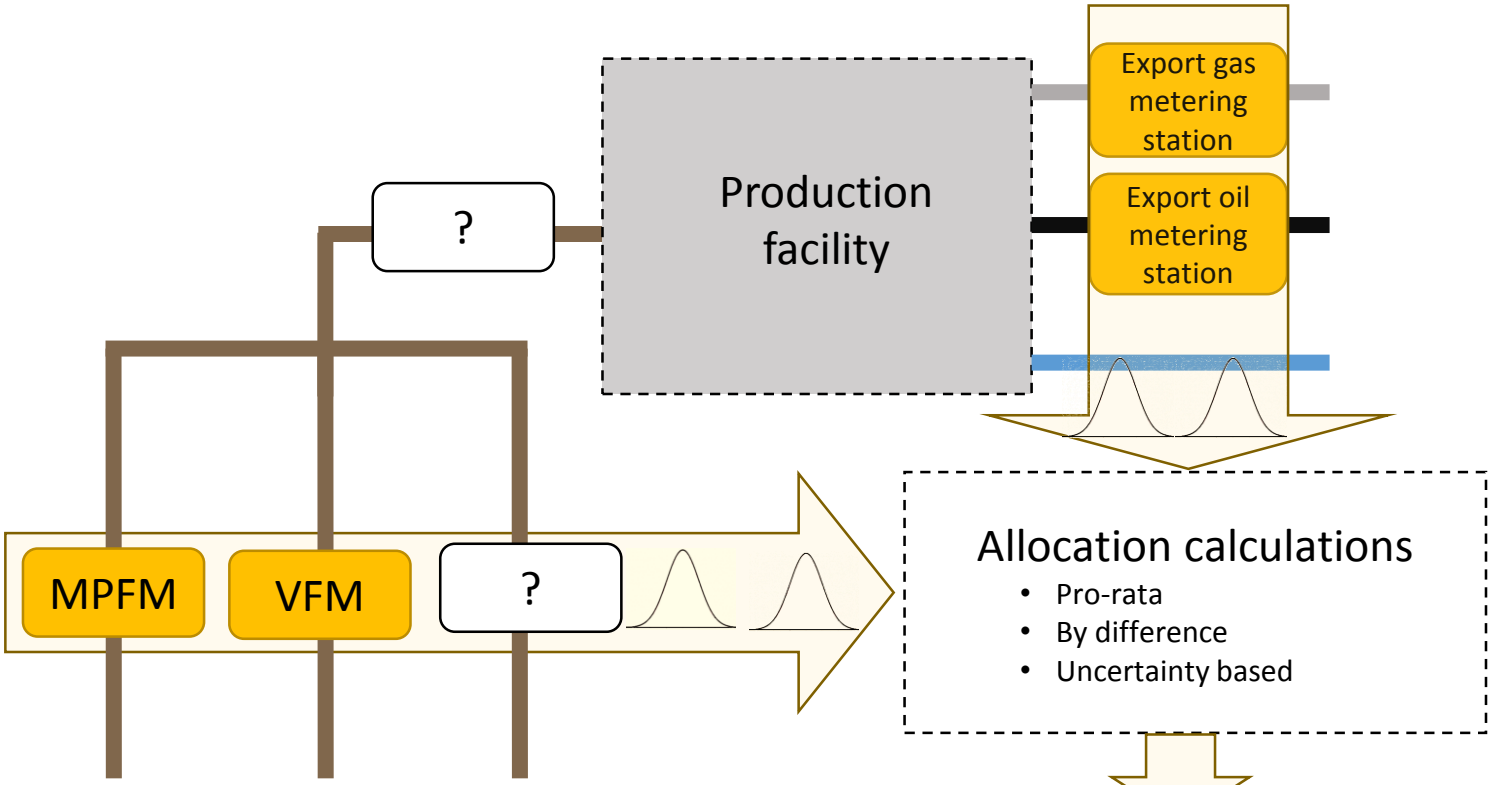
$$M_{x,i}^{oil,calc} = M_{x,i}^{HC} \cdot ORF_{x,i}$$

$$M_{x,i}^{oil,calc} = \left(M_{x}^{gas} w_{x,i}^{gas} + M_{x}^{oil} w_{x,i}^{oil} - M_{x}^{gas\ lift} w_{x,i}^{gas\ lift}\right) \cdot ORF_{x,i}$$

$$U^*\left(M_{x,i}^{oil,calc}\right)^2 = \left(\frac{M_{x}^{gas} w_{x,i}^{gas}}{M_{x,i}^{HC}} U^*\left(M_{x}^{gas}\right)\right)^2 + \left(\frac{M_{x}^{gas} w_{x,i}^{gas}}{M_{x,i}^{HC}} U^*\left(w_{x,i}^{gas}\right)\right)^2 + \left(\frac{M_{x}^{oil} w_{x,i}^{oil}}{M_{x,i}^{HC}} U^*\left(M_{x}^{oil}\right)\right)^2 + \left(\frac{M_{x}^{oil} w_{x,i}^{oil}}{M_{x,i}^{HC}} U^*\left(w_{x,i}^{oil}\right)\right)^2 + \left(\frac{M_{x}^{gas\ lift} w_{x,i}^{gas\ lift}}{M_{x,i}^{HC}} U^*\left(M_{x}^{gas\ lift}\right)\right)^2 + \left(\frac{M_{x}^{gas\ lift} w_{x,i}^{gas\ lift}}{M_{x,i}^{HC}} U^*\left(w_{x,i}^{gas\ lift}\right)\right)^2 + \left(U^*\left(ORF_{x,i}\right)\right)^2$$



# Modular logic and Monte Carlo simulation




Allocation calculations

- Pro-rata
- By difference
- Uncertainty based

Field allocation

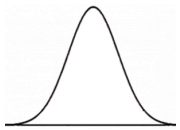
+ ownership matrix

Take any correlations into account!

Ownership allocation

+ sampling
+ flow rate estimates
+ HYSYS / PVT simulation uncertainties
for ORF / Kappa estimation

# Example: 2 fields – pro rata allocation of oil volume

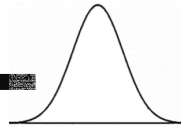


Sampling
→ PVT analysis
→ oil recovery factors (ORF)

Production facility

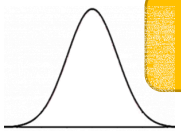
Export gas metering station

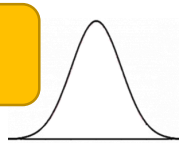
Export oil metering station



MPFM

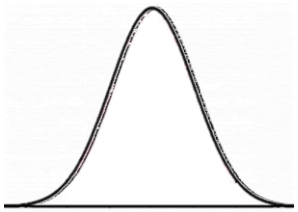
VFM





Field A

Field B



**Allocation calculations:**
HC mass, ORF → oil mass
oil mass, density → oil volume

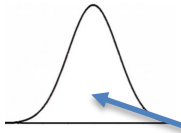
**Field allocated** oil volumes

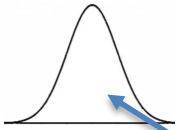
$$V_A = \frac{V_A}{V_A + V_B} V_{export}$$

$$V_B = \frac{V_B}{V_A + V_B} V_{export}$$

# Ownership allocation uncertainty

Field allocation:




| | Field A | Field B |
|---|---|---|
| Production [brl/h] | 1000 | 500 |
| U* [%] | 4 % | 8 % |
| U [brl/h] | 40 | 40 |

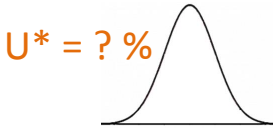
**Field allocated** uncertainties

Correlated distributions!

Ownership matrix:

| | Field A | Field B |
|---|---|---|
| Owner 1 | 30 % | 100 % |
| Owner 2 | 60 % | - |
| Owner 3 | 10 % | - |

Ownership allocation



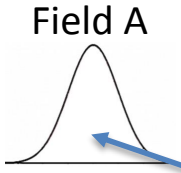
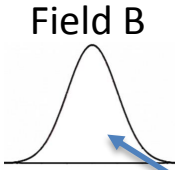

Owner 1


Owner 2


Owner 3

# Ownership allocation uncertainty

Field allocation:

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Correlated distributions!

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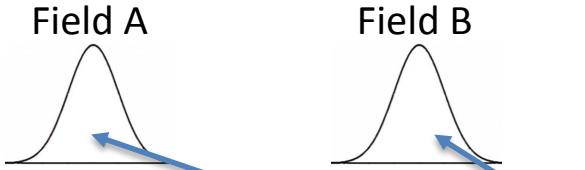
**Suggestion:**

$$U^*_{owner\ 1} = f(input\ measurements)$$

Write down **analytically** the equations relating the allocated quantities to each owner expressed in terms of the input parameters, including any conversions between volume and mass, component calculations etc. Then calculate the **sensitivity coefficients** associated with each input parameter, and perform an uncertainty analysis.

# Ownership allocation uncertainty

Field allocation:

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Correlated distributions!

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**Another suggestion:**

Multiply ***directly*** the field allocation uncertainties with the ownership matrix:

Rate allocated to owner 1: 0.3*1000 + 1*500= 800 brl/h

**Assuming correlation = 1:**

Absolute uncertainty: $0.3 \cdot 40 + 1 \cdot 40 = 52\ brl/h$

Relative uncertainty: **6.5 %**

**Assuming no correlations:**

Absolute uncertainty: $\sqrt{(0.3 \cdot 40)^2 + (1 \cdot 40)^2} = 42\ brl/h$

Relative uncertainty: **5.2 %**

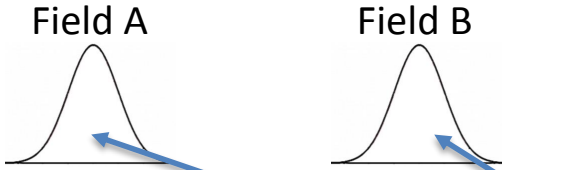
**Assuming correlation = -1 :**

Absolute uncertainty: $\mathrm{ABS}(0.3 \cdot 40 - 1 \cdot 40) = 28\ brl/h$

Relative uncertainty: **3.5 %**

# Ownership allocation uncertainty

Field allocation:

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Correlated distributions!

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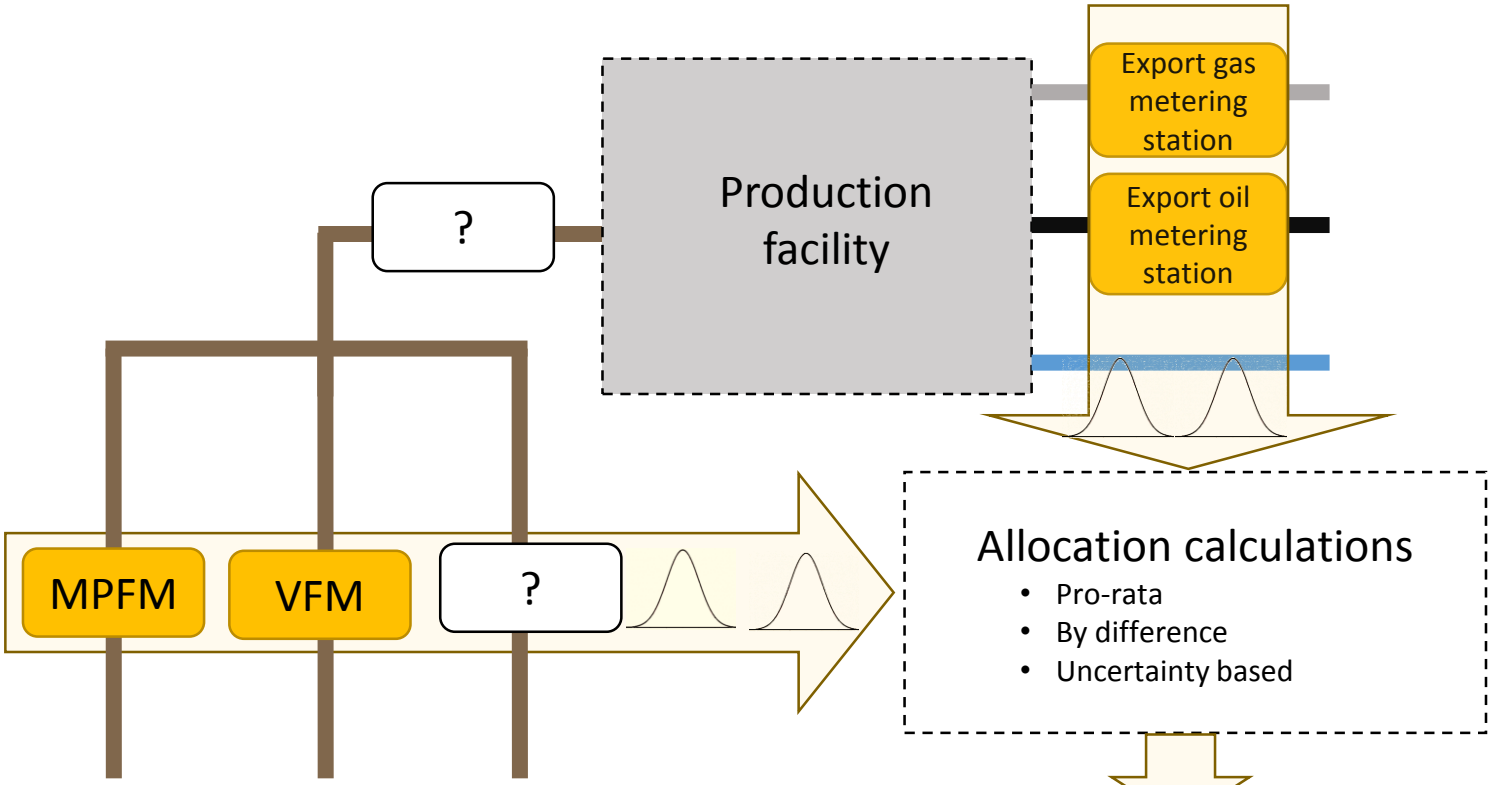
**Another suggestion:** Multiply the correlated field allocation **distributions** with the ownership matrix, then calculate the uncertainty from the width of the ownership allocation distribution:

Rate allocated to owner 1:

Absolute uncertainty from distribution: 2*σ

→ Relative uncertainty = **3.5 %**

# Modular logic and Monte Carlo simulation

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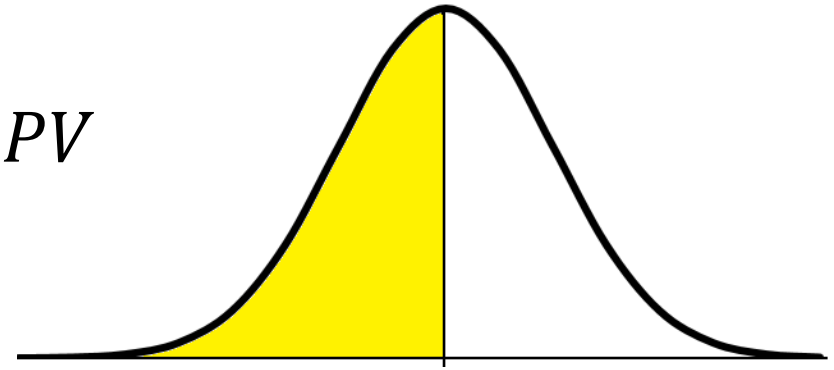
# Calculation of risk assocated with allocation uncertainty

$$Q = \frac{U^* \cdot NPV}{\sqrt{8\pi}} \approx 0.2 \cdot U^* \cdot NPV$$

(Stockton, 2009)



**Risk exposure for each owner:**
Ignoring correlations or assuming a correlation factor of +1 may result in errenous estimation of the economic risk each owner is exposed to

# Comparison with method based on ownership factor

NORSOK standard I-106 Edition 1, November 2014

**ANNEX C**
**System selection criteria (informative)**

(...)

In an allocation measurement between 2 production licenses the cost benefit analysis has to take into account that some of the partners may have ownership interests in both production licenses. The reason for this is that a partner with ownership interests in both production licenses will regain some of the loss as he is also owner in the other production license.

To account for this, the average difference in ownership between the production licenses has to be calculated. This can be done by summarizing the absolute value of the differences in ownership for all partners and divide the result by 2. A necessary presumption for performing cost benefit analysis is that all partners behave jointly to the benefit of the license group.

$$Average\ difference\ in\ ownership = \frac{1}{2} * \sum_{partner=1}^{n} ABS[(Share\ in\ license\ 1 - share\ in\ license\ 2\ )]$$

For allocation measurement concept B is acceptable if:

$(C_A – C_B) > (U_B – U_A)$ * Risk factor * NPV*Average difference in ownership.

# Comparison with method based on company relative risk

Method taking into account that the risk exposure and income must be calculated for each company separately

$$\frac{Company\ exposure}{Company\ income} = \frac{\sum_k E_k \cdot NPV_k \cdot U_k}{\sum_k E_k \cdot NPV_k}$$

From equation proposed in «Konseptvalg fiskale målinger» at NFOGM temadag 2014 (simplified here, no differentiation between the different production years)

$E_k$: Ownership in field k
$NPV_k$ : Net present value of field k
$U_k$: Field allocation uncertainty of field k

This method is comparable with multiplying directly the field allocation uncertainties with the ownership matrix

→ Method if field-allocated quantities have a correlation factor of +1

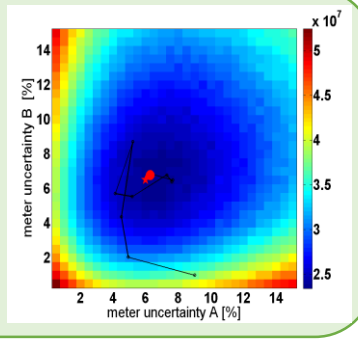
# Other interesting areas

**Risk analysis**

CAPEX + OPEX
Allocation uncertainty
Flow rates
Ownership matrix
→ **Economic risk**

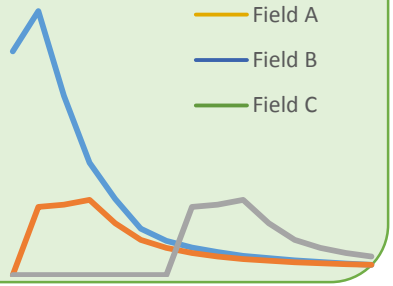
**Meter uncertainty optimization**

- CAPEX
- OPEX
- Calibration interval



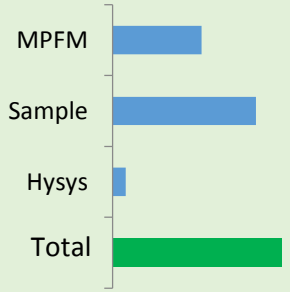

**Lifetime analysis**

- Flow rate variations
- Production decline
- Increasing GOR



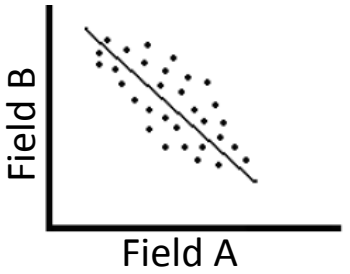

**Uncertainty budgets**

- Sensitivity to input parameters
- Identifying the most significant contributions

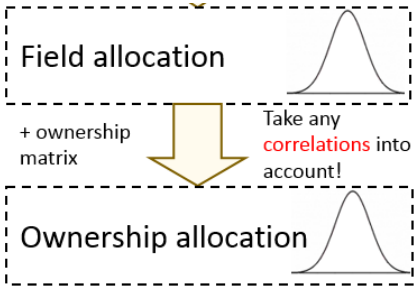


# Summary

- When flows are combined in an allocation system this results in correlation between the field allocated quantities




- This correlation must be taken into account in the ownership uncertainty and risk calculations




- These effects are often not intutive→ an analysis must be carried out