NFOGM
NORWEGIAN SOCIETY FOR OIL AND GAS MEASUREMENT

Use uncertainty to handle economical risk in allocation systems

Tekna

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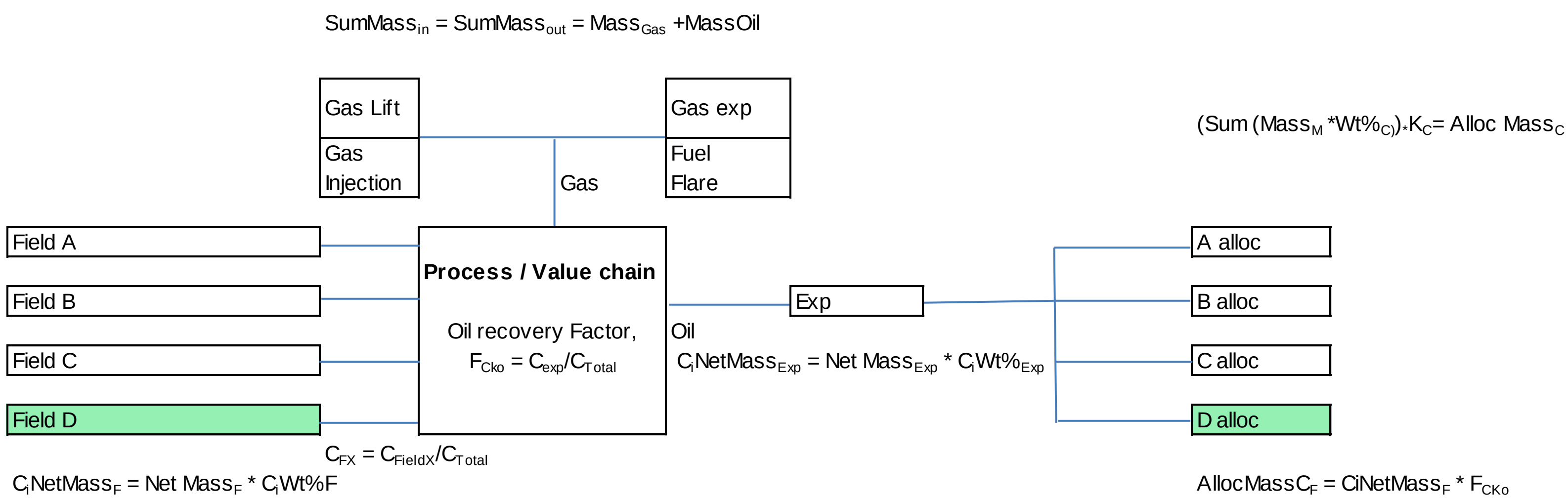
Potensial case

- A Host field has the capacity of a new 3.party Tie–in field and the possibility of re-use of existing tie-in facilities.
- The production profile for the tie-in field show a much higher oil rate than the Host for the first few years and then it declines quickly. Gas production is almost similar to the Host.
- The Host facility is mature and has limited space.
- The technical study of the tie-in showed few and small restriction.
- The technical decision was “go”.

HM and HVR study

- How will the tie-in field effect the Host's hydrocarbon field allocation?
  - The Host's field allocation practice is "By-difference" (no measurement of Host production)
  - Hysis simulation is used to give the ORF (oil recovery factors)
  - Oil export goes to pipeline and the gas is injected into the reservoir.

Simplified uncertainty and risk model



Uncertainty oil calc:

Identified uncertai	unit	**A**	**B**	**C**	**Exp**	**D by difference**	Comments
Measured Relative	%	0,6	0,6	0,6	0,3		Measurement uncertainty calc
Water Wt %	%	0,5	0,5	0,5	0,5		ISO 3171 and API 10.9 (0-5 W%t
Sampling incl. ana	%	3	3	3	3		ISO 3171 and ASTM D 1945 (Se
Process Issues	%	0	0	0	0		Bias (Best guess?)
Oil recovery Fact	%	5	5	5			a) Hysis simulation 5-15%
Mass	Tonnes	60 000	15 000	7 500	112 500	30 000	
Alloc Relative unc	%	5,88	5,88	5,88	3,06	16,75	
Alloc Absolute un	Tonnes	3 530	882	441	3 438	5 025	

$uD^2 = uA^2 + uB^2 + uC^2 + u_{Exp}^2$

A disturbing result needs further investigation.

Updated uncertainty:

- Contacted a professional company for a more detailed uncertainty calculation for “by-difference” allocation and ownership.

- Updated with:

Uncertainty oil calc:

Identified uncertai	unit	A	B	C	Exp	D by difference	Comments
Measured Relative	%	0,6	0,6	0,6	0,3		Measurement uncertainty calc
Water Wt %	%	0,5	0,5	0,5	0,5		ISO 3171 and API 10.9 (0-5 W%t
Sampling incl. ana	%	3	3	3	3		ISO 3171 and ASTM D 1945 (Se
Process Issues	%	0	0	0	0		Bias (Best guess?)
Oil recovery Facto	%	10	10	10			a) Hysis simulation 5-15%
Mass	Tonnes	60 000	15 000	7 500	112 500	30 000	
Alloc Relative unc	%	10,47	10,47	10,47	3,06	24,58	
Alloc Absolute un	Tonnes	6 282	1 570	785	3 438	7 373	

$uD^2 = uA^2 + uB^2 + uC^2 + u_{Exp}^2$

Uncertainty to improve

- Result not acceptable – what to do?
- Highest contributor – ORF
  - Improve or eliminate

Uncertainty oil calc:

Identified uncertai	unit	A	B	C	Exp	D by differe nce	D Pro rata	Comments
Measured Relative	%	0,6	0,6	0,6	0,3		0,6	Measurement uncertainty calc
Water Wt %	%	0,5	0,5	0,5	0,5		0,5	ISO 3171 and API 10.9 (0-5 W%t)
Sampling incl. ana	%	3	3	3	3		3	ISO 3171 and ASTM D 1945 (Sens
Process Issues	%	0	0	0	0		0	Bias (Best guess?)
Oil recovery Facto	%	10	10	10			1	a) Hysis simulation(Monte Carlo sim. Appr 10%
Allocated Mass	Tonnes	60 000	15 000	7 500	112 500	30 000	30 000	
Alloc Relative unc	%	10,47	10,47	10,47	3,06	24,58	3,26	
Alloc Absolute un	Tonnes	6 282	1 570	785	3 438	7 373	977	

Simplified risk model

Value calc:

Components:	unit	A	B	C	Exp	D by difference	D Pro rata	Comments
Oil density	Kg/Sm3	0,79	0,78	0,72	0,73	0,78	0,78	
Vol Sm3	Sm3	75949	19231	10417	154110	38462	38462	
1Sm3 = 6,3 bbl	bbl/Sm3	6,3	6,3	6,3	6,3	6,3	6,3	
Vol BBl	bbl/Sm3	478 481	121 154	65 625	970 890	**242 308**	**242 308**	
$ pr bbl	$/bbl	50	50	50	50	50	50	
NPV; value of production	$	23 924 051	6 057 692	3 281 250	48 544 521	12 115 385	12 115 385	

Calc value for D:

Components:	unit	A	B	C	Exp	D by difference	D Pro rata	Comments
Ownership	factor	0,30	0	0		0,50	0,50	Company ownership in licence
Income $	$	7 177 215	0	0		6 057 692	6 057 692	
Total Income $	$					13 234 907	13 234 907	Value of ownership (Correlation?)

Value of possible bias:

Components:	unit	A	B	C	Exp	D by difference	D Pro rata	Comments
R=0,2*U*NPV (Production)	bbl					21 308	1 724	
R=0,2*U*NPV (Value)	$					1 065 410	86 220	

Risk is Consequense multiplied with Probability

High difference in uncertainty and production gives a high probability for bias.

Oil bias calculation

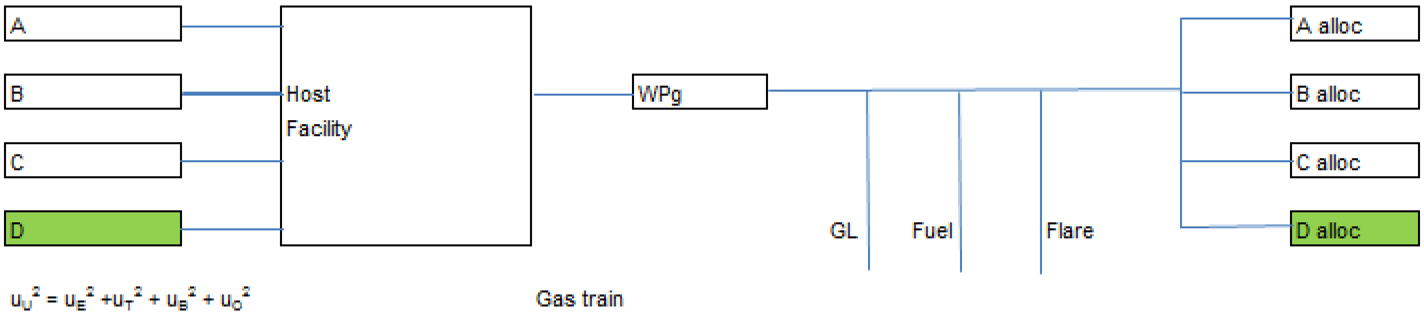
Year	Production in bbl: A mstb/d	B mstb/d	C mstb/d	D mstb/d	Uncertainty by difference: A %	B %	C %	D %	Uncertainty pro rata: A %	B %	C %	D %	Potential Bias: By diff bbl/y	By pro rata bbl/y
2018	3,26	2,0	0	12,47	10,7	10,7	0,0	5,6	4,9	4,8	0,0	3,0	50 228	24 162
2019	6,57	1,7	35	11,60	10,7	10,7	10,8	37	4,7	4,6	3,1	4,4	263 316	39 510
2020	7,17	1,6	35	14,13	10,7	10,7	10,8	38	4,7	4,6	3,2	4,3	325 220	44 766
2021	7,42	1,5	35	16,35	10,7	10,7	10,8	28	4,7	4,6	3,2	4,1	275 937	47 918
2022	5,71	1,3	31	15,49	10,7	10,7	10,8	27	4,7	4,6	3,3	4,0	239 952	42 814
2023	3,65	1,2	15	13,18	10,7	10,7	10,8	17	4,7	4,5	3,6	3,7	130 326	32 395
2024	1,82	1,2	8	14,11	10,7	10,7	10,8	9,3	5,0	4,7	4,3	3,3	76 469	28 428
2025	2,09	1,0	4,4	11,24	10,7	10,7	10,8	8,1	4,9	4,7	4,5	3,1	52 134	20 774
2026	2,39	1,0	3,3	9,56	10,7	10,7	10,8	7,6	4,7	4,7	4,5	3,1	47 448	19 203
2027	2,04	0,9	2,9	8,56	10,7	10,7	10,8	8,0	4,9	4,7	4,6	3,1	40 639	9 167
2028	1,57	0,0	2,7	7,22				7,4	4,9	4,5	4,7	3,1	28 045	14 428
													1 529 715	323 565

The economical bias is significant reduced with Pro-rata.

Gas uncertainty

Simplified uncertainty calculation for gas bias “pro-rata”.

$(Sum\ (Mass_M * Wt\%_{C}))-K_C = Alloc\ Mass_C$



$u_U^2 = u_E^2 + u_T^2 + u_B^2 + u_O^2$

Uncertainty calc Gas:

Identified uncertainty	unit	A	B	C	D	Comments
Measured Relative uncertainty	%	4	2	2	2	According to uncertainty calc (KS)
Sampling	%	3	3	3	3	According to ISO 3171 + wet gas
Analyze	%	2,5	2,5	2,5	2,5	ASTM D 1945 (Sensitivity C1+ highest)
Process instability	%	1	1	1	1	Best guess
Allocation calculation WPg	%	1	1	1	1	Calculation is correct, but assumption on gas quality + Mass to Vol
Gas Lift	%	0	2	0	4	D 4 , B 1
Fuel	%	4,5	4,5	4,5	4,5	x fuel gas meters
Flare	%	11	11	11	11	y Flare meter, assume z in daily use
Export/Sales gas/gas inj	%	0	0	0	0	No measurement
Alloc Relative uncertainty	%	**13,21**	**12,90**	**12,75**	**13,36**	
Alloc Absolute uncertainty	Tonnes	0,00	0,00	0,00	0,00	

Gas risk

- Gas bias and cost calculation related to the production prognosis carried out.
- Change in gas measurement uncertainty to 15% could not fully justify installation of a gas metering station.

Case closed?

- Conclusion and Recommendation:
  - High possibility for bias on oil for Host, due to the difference in oil production profiles combined with high uncertainty for (no) oil measurement and sampling.
  - Recommend change from by-difference to pro-rata allocation to mitigate risk.
  - Installation of a new oil metering and sampling stations for Host can be well justified.
  - There is low probability for economical bias on gas for Host, due to gas injection and no gas sale and the gas from the Host has low influence on the oil allocation.
  - Use theoretical values to determine the gas production for Host and installation a spot sampling point for the comingled gas stream.

Then what if……

- No space for oil metering and sampling stations
- No financial commitment to invest as recommended.

Is it possible to use the uncertainty and risk calculation in the allocation program to cover for the risk of losses?

Cover risk in allocation….

- Risk is equal to probability multiplied with consequence.
- If the probability is “high high” for bias it could theoretical be possible to design an allocation uncertainty model to cover for negative bias.
- An uncertainty model can be designed to calculate the uncertainty by mass, volume or per component mass.
- The uncertainty calculation can be installed and compute in relation with the allocation program and use the same production numbers and thereby calculate the theoretical bias on the actual numbers.

Cover risk in allocation….

- For instance bias correction could be performed post allocation on component basis.

Host:					Tie-in		
Comp.	Oil mass	Risk %	Risk mass	New Oil mass	Oil mass	Risk mass	New Oil mass
N2	0	3,00	0,00	0	0	0,00	0
CO2	5	2,50	0,13	5	20	-0,13	20
C1	75	2,10	1,57	76	100	-1,57	98
C2	100	2,00	2,00	102	230	-2,00	228
C3	150	1,00	1,50	152	500	-1,50	499
i-C4	100	0,30	0,30	100	400	-0,30	400
n-C4	220	0,30	0,66	221	900	-0,66	899
i-C5	150	0,25	0,38	150	850	-0,38	850
n-C5	200	0,25	0,50	201	1000	-0,50	1 000
C6	550	0,20	1,10	551	4000	-1,10	3 999
C7+	8450	0,20	16,90	8 467	42000	-16,90	41 983
Sum	10 000		25,03	10 025	50 000	-25,03	49 975

$$R_A = 0,2 * U_{ACj} * Mass_{ACj}$$

Bias probability

- The “probability” is dependent on (ref. K.E. Føysa’s paper last HM workshop)
  - production rates
  - measurement uncertainties
  - sampling and analysis results
  - combination of the above.

Probability related to production:

Host	Tie-in	$P_{A\ Host}$
%	%	%
10	90	**HH**
25	75	**H**
50	50	**L**

- The “probability” for the consequence over the life time of the Field is needed due to change in production rates.
- Is it possible to include a “probability” factor in the equation for Risk to be able to establish bias?

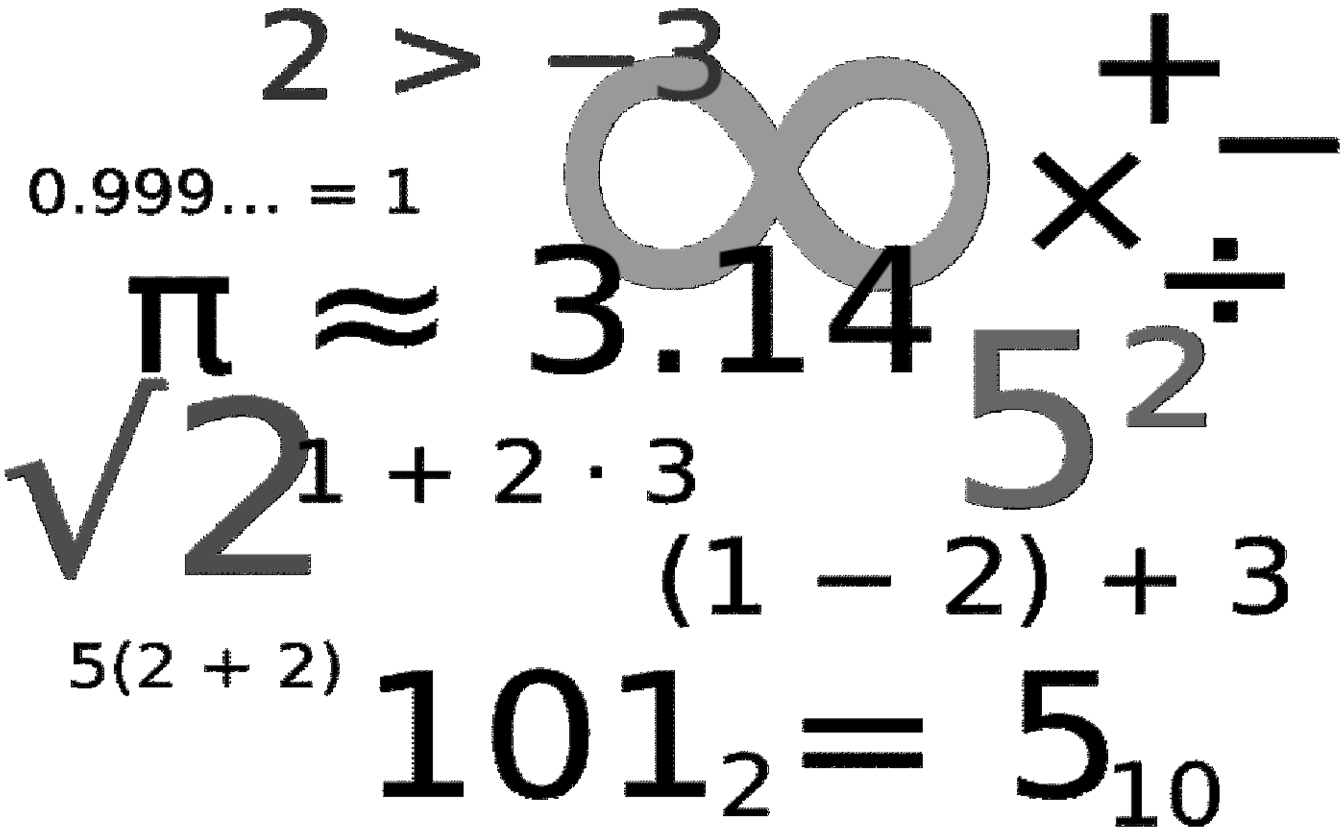
$$R_A = 0{,}2 * U_A * RNV_A * P_A$$

May and may not….

Uncertainty models and risk calculation can give a lot of information to unveil and mitigate for potential economical bias/losses, but may not be framed at this point to be used in the daily allocation.

Uncertainty analysis involves a lot of uncertainties.

Thank you....!



Any comments or questions?