Cost benefit analysis for measurement at pipeline entry

NFOGM Hydrocarbon management

Field allocation

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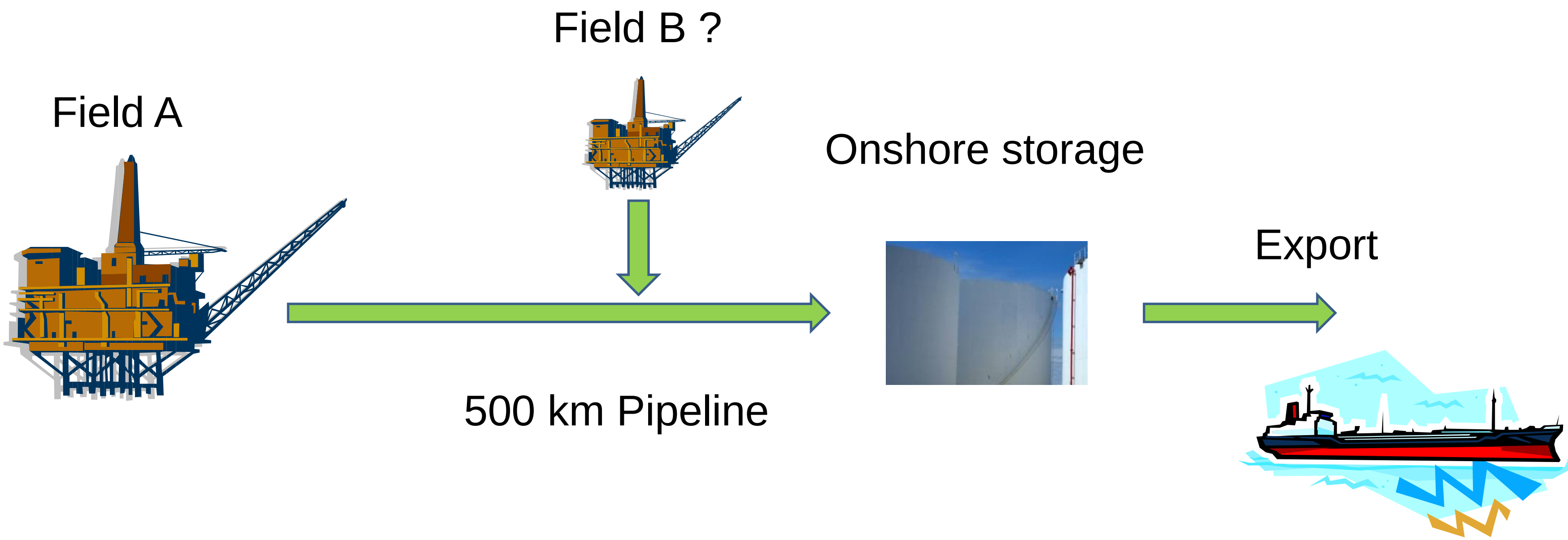
Introduction



- New field development with Field A, pipeline, onshore storage and export
- There **migth** be future tie ins to the pipeline: Field B
- Should we install a conventional metering station at the pipeline entry from field A?
- Metering at pipeline entry from field A will be used for allocation between A and B

Authority requirements (Norway)

- The purpose of these regulations is to ensure that accurate measurements form the basis of the calculation of taxes, royalties and fees etc. to the Norwegian state, including the CO_2 tax, and the income of the licensees.
- §4 Activities as mentioned in Section 1 of the present regulations shall be carried out in accordance with requirements stipulated by or pursuant to these regulations, and
in accordance with recognised standards for such activities.
- Comments to § 4
The use of recognised standards as mentioned in the first paragraph is optional inasmuch as other technical solutions, methods or procedures may be selected.
The basis for using alternative methods may be:
a) documentation demonstrating that measuring uncertainty and operational reliability is equal to or better than conventional equipment,
b) in metering for allocation purposes, when there is a cost disproportion between a conventional system compared to a simplified system ref NORSOK

Maximum allowed measurement uncertainty for liquid = 0,30 % of standard volume

Basic principle of cost benefit analysis

- Simplified solution may be acceptable if cost saving is larger than the increased risk
- Similarities in ownership has to be taken into account.
- See NORSOK standard for fiscal measurement for details
  (Relevant appendix will be improved in new revision of the NORSOK standard)

Frame conditions

- Be aware that normally, offshore facillities has

- Weight limitations because every tonn has a cost
- Space limitations because every square meter has a cost
- Limited amounts of beds in the living quarter
- Hard competition and prioritization between possible modification projects
- Total direct and indirect costs over the life time of the metering system are much higher than the purchase order value.

You need a sufficient argument for
every piece of equipment you put in the design

Options to prepare for a possible future tie-in

- Install metering system from start:

1. Install conventional metering station from start
2. Install simplified metering station from start

- Reserve place and weight reserves and plan for:

3. Future installation of a conventional metering station
4. Future installation of a simplified metering station

- Make no preparations:

5. Plan to measure field A by difference

Conventional solution example

Conventional offshore metering station:

- Weight: 100 tonn
- Size: 15 m X 5 m X 5 m
- Package cost: **5 000 000 EUR**
- Life cycle cost **20 000 000 EUR**
- Life cycle uncertainty < 0,15 %

Note that detail design will vary depending on many factors including fluid and and maximum capacity

Simplified solution - example

Simple metering station:

- Weight: 10 tonn
- Size: 15 m X 1 m X 1 m
- Package cost: 1 000 000 EUR
- Life cycle cost 4 000 000 EUR
- Life cycle uncertainty < 0,3 %

- The design of a simplified metering station is determined on a case to case basis.
- A single metering run with two meters in series is the simplest metering system we can imagine. (The concept is already used for gas).

Simplest solution - Measurement by difference

Measurement by difference:
(Long term effect)

Field A = Export – Field B

Simplest:

- Weight: 0 tonn
- Size: 0 m X 0 m X 0 m
- Package cost: **0 000 000 EUR**
- Life cycle cost **0 000 000 EUR**
- Uncertainty < ?

Uncertainty for measurement by difference

$$Allocated\ to\ field\ A = Measured\ Export\ - Measured\ import\ from\ field\ B$$

$$Uncertainty\ field\ A\ (m^3) = \sqrt{((Uncertainty\ export^2) + (Uncertainty\ field\ B^2))}$$

Uncertainty from measurement by difference

Production from field A = export from the onshore terminal C - production from field B								
Export from the onshore terminal C			**Production from field B**			**Allocated to field A**		
Amount	**Uncertainty**	**Uncertainty**	**Amount**	**Uncertainty**	**Uncertainty**	**Amount**	**Uncertainty**	**Uncertainty**
m3	**%**	**m3**	**m3**	**%**	**m3**	**m3**	**m3**	**%**
100	0,15	0,15	0	0,15	0,000	100	0,15	0,15
100	0,15	0,15	10	0,15	0,015	90	0,15	0,17
100	0,15	0,15	20	0,15	0,030	80	0,15	0,19
100	0,15	0,15	30	0,15	0,045	70	0,16	0,22
100	0,15	0,15	40	0,15	0,060	60	0,16	0,27
100	0,15	0,15	50	0,15	0,075	50	0,17	0,34
100	0,15	0,15	60	0,15	0,090	40	0,17	0,44
100	0,15	0,15	70	0,15	0,105	30	0,18	0,61
100	0,15	0,15	80	0,15	0,120	20	0,19	0,96
100	0,15	0,15	90	0,15	0,135	10	0,20	2,02

- It is here assumed that a conventional metering system
  will have a long term uncertainty of 0,15% (lower than the required 0,3%)
- Relative uncertainty for the amount allocated to A increases when A gets smaller!

Uncertainty when all streams are measured

When all inputs and all outputs are measured each of the inputs are adjusted pro rata to match the measured output:

$$Allocated\ to\ A = f(Meas\ A, Meas\ B, Export) = Meas\ A * \frac{Export}{Meas\ A + Meas\ B}$$

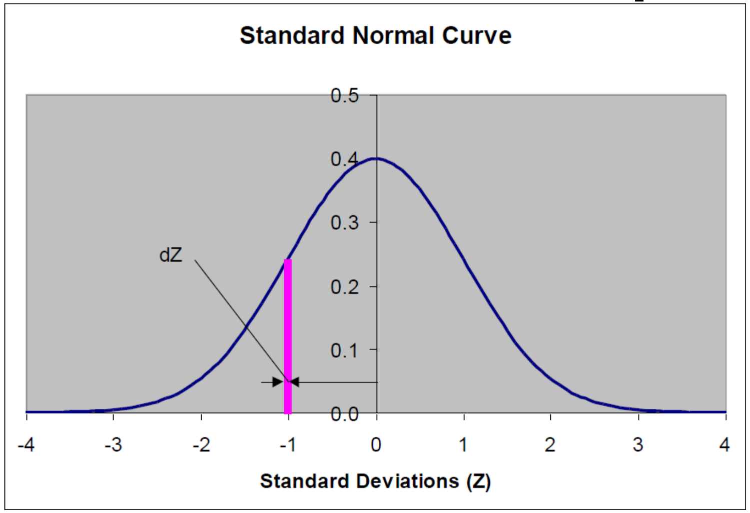
$$Uncertainty\ A\ (m^3) = \sqrt{\left(\frac{df}{dA}\right)^2 * Meas\ unc\ A^{\ 2} + \left(\frac{df}{dB}\right)^2 * Meas\ unc\ B^2 + \left(\frac{df}{dExport}\right)^2 * Export^2}$$

$$\left(\frac{df}{dA}\right) = Meas\ B\ * \left(\frac{Export}{(Meas\ A)^2 + (2 * Meas\ A * Meas\ B) + (Meas\ B)^2}\right)$$

$$\left(\frac{df}{dB}\right) = Meas\ A\ * \left(\frac{Export}{(Meas\ A)^2 + (2 * Meas\ A * Meas\ B) + (Meas\ B)^2}\right)$$

$$\left(\frac{df}{dExport}\right) = \frac{Meas\ A}{(Meas\ A + Meas\ B)}$$

Uncertainty vs. risk for loss Phillip Stocton (NSFMW 2009)



Probability for an error in an interval is equal to the area under the curve in this interval.

$$Risk\ for\ loss = \int_{0}^{-\infty} (Probability * error)$$

$$Risk\ for\ loss \neq Uncertainty\ @\ 2\ standard\ deviations$$

$$Risk = Probability * consequence$$

$$Risk\ for\ loss\ (m^3) = \mathbf{0,2} * (Uncertainty\ @\ 2\ Standard\ deviations)$$

$$Risk\ for\ loss\ (EUR) = Risk\ for\ loss\ (m^3) * Value\ \left(\frac{EUR}{m^3}\right)$$

Benefit of transposing uncertainty to risk

Risk for loss from measurement uncertainty and costs are comparable units

Risk for loss from meas. uncertainty [EUR] = Risk for loss of income [EUR]

Risk for loss of income = Risk for loss of profit

Cost [EUR] * 1 = Risk for loss of profit [EUR]

Systematic errors are also comparable to risk for loss from measurement uncertainty and cost

Size of systematic error [EUR] * 1 = Risk for loss of income [EUR]

Input			Base case
Field A net present value of planned production from tie in date	Value of production	EUR	15E+9
Field B net present value of production from third party from tie in date	Value of production	EUR	40E+9
Total export from C = A + B	Value of export	EUR	55E+9
Uncertainty of total export measurement @95% confidence level.	Uncertainty	%	0,15
Life cycle cost of conventional metering system at pipeline entry from field A	Life cycle cost	EUR	20E+6
Uncertainty of conventional pipeline entry measurement @95% confidence	Uncertainty	%	0,15
Life cycle cost of simplified metering system at pipeline entry from field A	Life cycle cost	EUR	4E+6
Uncertainty of simplified pipeline entry measurement from @95% confidence	Uncertainty	%	0,3
Uncertainty of field B pipeline entry measurement @95% confidence level	Uncertainty	%	0,15
Risk factor: Risk for loss / Uncertainty @ 95% confidence level	Risk factor		0,2
Output			
Option 1: Measurement of field A by difference			
Field A: risk for loss from measurement uncertainty if field A is only exporter through C	Risk for loss	EUR	-4,5E+6
Field A: Risk for loss from measurement uncertainty if determined by difference = C - B	Risk for loss	EUR	-20,4E+6
Increased risk for loss for Field A if the field is determined by difference rather than being alone and be determined from export metering	Risk for loss	EUR	-15,9E+6
Option 2: Install conventional metering system at pipeline entry from field A			
Combined risk for loss from measurement uncertainty for field A	Risk for loss	EUR	-6,5E+6
Risk reduction for Field A if the field is measured conv. rather than determined by difference	Risk reduction	EUR	13,9E+6
Life cycle cost of conventional metering system at pipeline entry from field A	Cost	EUR	-20,0E+6
Net value of a conventional metering system rather than determined by difference	Value	EUR	-6,1E+6
Option 3: Install simplified metering system at pipeline entry from field A			
Combined risk for loss from measurement uncertainty for field A	Risk for loss	EUR	-8,6E+6
Risk reduction if the field is measured simpl. rather than determined by difference	Risk reduction	EUR	11,8E+6
Life cycle cost of simplified metering system at pipeline entry from field A	Cost	EUR	-4,0E+6
Net value of a simplified metering system rather than determined by difference	Value	EUR	7,8E+6
Cost proportion between installing a simplified system rather than a conventional system			
Net value of a simplified system rather than a conventional system	Value	EUR	14E+6

Additional information

- There will be a process metering station at pipeline entry
- The flow rates will have fallen below 50 % of original flow rates before it will be relevant to install a simplified metering system for a future tie-in
- A future simplified system can be of smaller diameter than the prossess measurement installed from day one
- We can prepare for a future simplified metering station by just making sure that:
  - Flange to flange length is sufficient for installation of a: future simplified metering system
  - There is a flanged spool for installation of a: future mixer with sample probes.
  - There is room for a future sampling cabinet
- The weight of a simplified metering system will be similar to the process metering station.

Conclusion

The conclusion we made was to:

- Reserve place ~~and weight reserves~~ and plan for:

4. Future installation of a simplified metering station

- Measurement by difference will be a feasible back-up method