The NPDs view on uncertainty and ensembles

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NPD's objective is to contribute to the greatest possible values for Norwegian society from the oil and gas activities through efficient and responsible resource management where health, safety, the environment and other users of the sea are taken into consideration.

NORWEGIAN PETROLEUM DIRECTORATE
50 years

Professional adviser to the Ministry of Petroleum and Energy.

☆ National responsibility for the data from the Norwegian continental shelf.

Follow-up the petroleum activities in cooperation with other authorities.

☆ Driving force for realising the resource potential through a strategic Norwegian continental shelf perspective.

In general, as an industry are we

comfortable and competent using Statistics?
good at Estimating?
good at Making Decisions?

What is a good decision?

- A good decision is defined as
  - “an action we take that is logically consistent with our objectives and preferences,
  - the alternatives we perceive and
  - the information we have”
- Good outcome ≠ good decision
- To ascertain whether a decision is good or not, the focus should be on the decision-making process, not on outcomes.

- We can increase the probability of good outcomes by improving decision making.

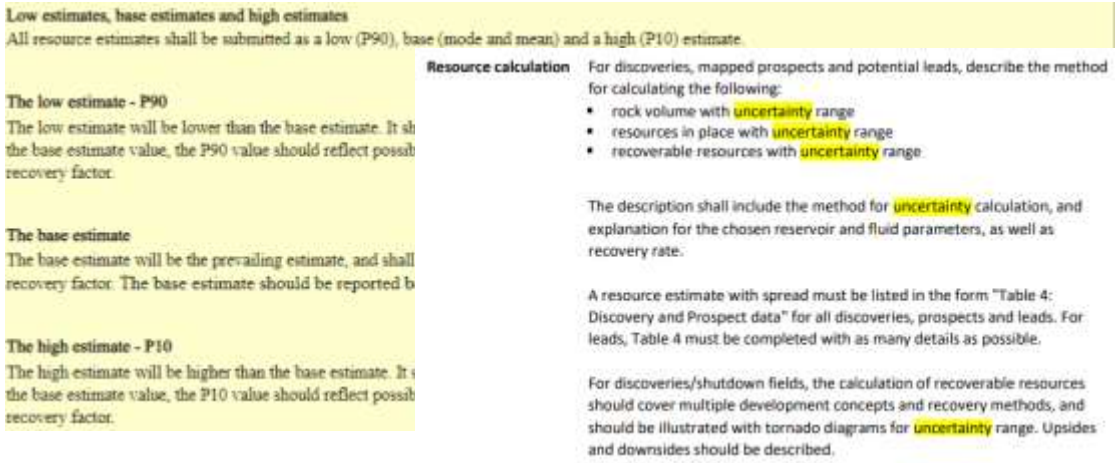
Good Decisions & Human Nature

- Decision making, by its nature, incorporates uncertainty
- Universal tendency is to understate uncertainty
- This happens because most people are…
  - Too sure of themselves and their judgments
  - Too attached to their analysis
  - Not open to considering other information and opinions

! Be aware of biases and strive for rational decision making

Reporting of possible outcome ranges to the NPD

- APA



Low estimates, base estimates and high estimates
All resource estimates shall be submitted as a low (P90), base (mode and mean) and a high (P10) estimate.

The low estimate - P90
The low estimate will be lower than the base estimate. It sh
the base estimate value, the P90 value should reflect possib
recovery factor.

The base estimate
The base estimate will be the prevailing estimate, and shall
recovery factor. The base estimate should be reported b

The high estimate - P10
The high estimate will be higher than the base estimate. It
the base estimate value, the P10 value should reflect possib
recovery factor.

Resource calculation For discoveries, mapped prospects and potential leads, describe the method for calculating the following:

- rock volume with uncertainty range
- resources in place with uncertainty range
- recoverable resources with uncertainty range

The description shall include the method for uncertainty calculation, and explanation for the chosen reservoir and fluid parameters, as well as recovery rate.

A resource estimate with spread must be listed in the form "Table 4: Discovery and Prospect data" for all discoveries, prospects and leads. For leads, Table 4 must be completed with as many details as possible.

For discoveries/shutdown fields, the calculation of recoverable resources should cover multiple development concepts and recovery methods, and should be illustrated with tornado diagrams for uncertainty range. Upsides and downsides should be described.

- PDO

Uncertainty is mentioned 23 times in the PDO/PIO guideline

- Subsurface
- Safety risks
- Measurement systems
- Costs / profitability

- RNB

… All estimates shall be given with uncertainty, i.e., high (preferable P10), low (preferable P90) and base estimate (expected value) …

2) Resource overview

Risk distribution. State probability that the outcome will be greater than or equal to the low/high value	Low (%)	Base	High (%)

Recoverable resources and reserves in classes lower than 6 shall be reported directly in the applicable profile collection. A total overview of the reported resources can be found in the Resource Overview - "Ressursoversikt" spreadsheet Ressource Overview

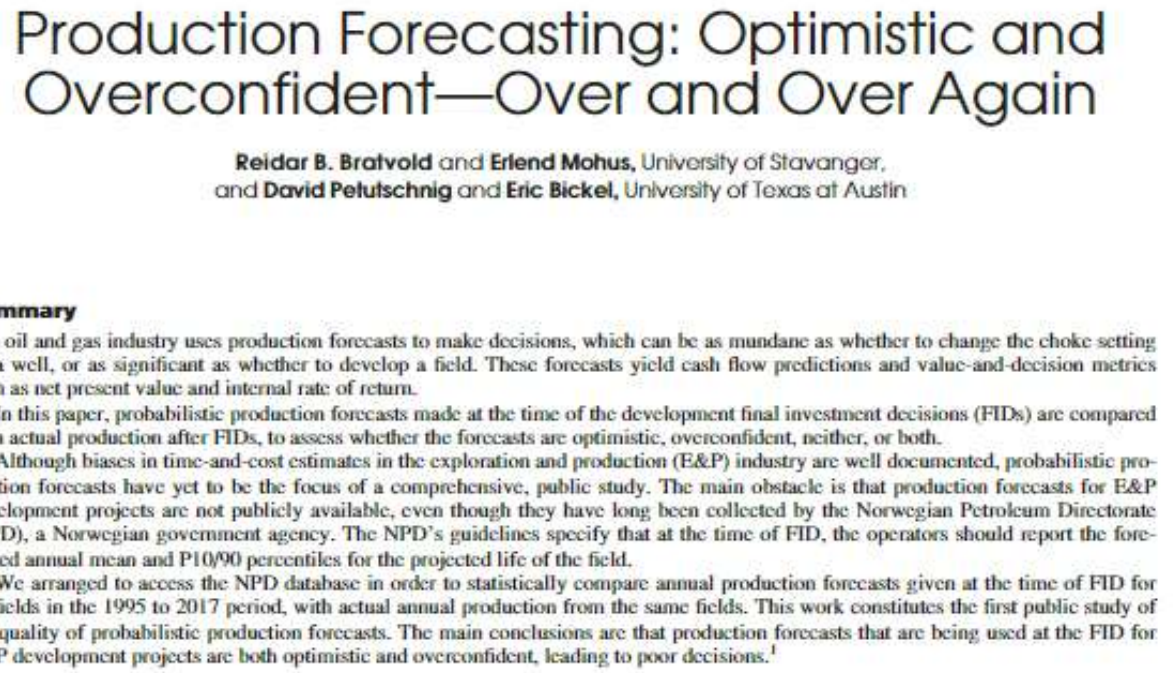
Table 3-4 Uncertainty categories

Uncertainty category	Definition	Explanation
Low estimate (L)	Low estimate of petroleum volumes that are expected to be recovered from a project.	The low estimate must be lower than the base estimate. The probability of being able to recover the indicated estimate or more must be shown (e.g., P90). Compared with the base estimate, the low estimate should express potential negative changes with regards to mapping of the reservoir, reservoir/fluid parameters and/or recovery rate.
Base estimate (B)	Best estimate of petroleum volumes that are expected to be recovered from a project.	The base estimate must reflect the current understanding of the scope, properties, and recovery rate of the reservoir. The base estimate will be calculated using a deterministic or stochastic method. If the base estimate was calculated using a stochastic method, the base estimate shall be stated as the expected value.
High estimate (H)	High estimate of petroleum volumes that are expected to be recovered from a project.	The high estimate must be higher than the base estimate. The probability of being able to recover the indicated estimate or more must be shown (e.g., P10). Compared with the base estimate, the high estimate should express potential positive changes with regards to mapping of the reservoir, reservoir/fluid parameters and/or recovery rate

https://www.npd.no/regelverk/rapportering/revidert-nasjonalbudsjett/

Are production forecasts any good?

- Study by Bratvold et al presented in 2019 (SPE-195914-PA) concludes that production forecasts @ FID are both optimistic and overconfident.
- Further work done in the Decision and Data Analytics Group, IER @ University of Stavanger on Debiasing oil production Forecasts on the NCS
  - Forecasts are heavily biased both at the time of the FID and after production start, across time and field characteristics
  - As an industry we haven't gotten any better!



Production Forecasting: Optimistic and Overconfident—Over and Over Again

Reidar B. Bratvold and **Erlend Mohus**, University of Stavanger,
and **David Pelutschnig** and **Eric Bickel**, University of Texas at Austin

Summary

The oil and gas industry uses production forecasts to make decisions, which can be as mundane as whether to change the choke setting on a well, or as significant as whether to develop a field. These forecasts yield cash flow predictions and value-and-decision metrics such as net present value and internal rate of return.

In this paper, probabilistic production forecasts made at the time of the development final investment decisions (FIDs) are compared with actual production after FIDs, to assess whether the forecasts are optimistic, overconfident, neither, or both.

Although biases in time-and-cost estimates in the exploration and production (E&P) industry are well documented, probabilistic production forecasts have yet to be the focus of a comprehensive, public study. The main obstacle is that production forecasts for E&P development projects are not publicly available, even though they have long been collected by the Norwegian Petroleum Directorate (NPD), a Norwegian government agency. The NPD's guidelines specify that at the time of FID, the operators should report the forecasted annual mean and P10/90 percentiles for the projected life of the field.

We arranged to access the NPD database in order to statistically compare annual production forecasts given at the time of FID for 56 fields in the 1995 to 2017 period, with actual annual production from the same fields. This work constitutes the first public study of the quality of probabilistic production forecasts. The main conclusions are that production forecasts that are being used at the FID for E&P development projects are both optimistic and overconfident, leading to poor decisions.[1]

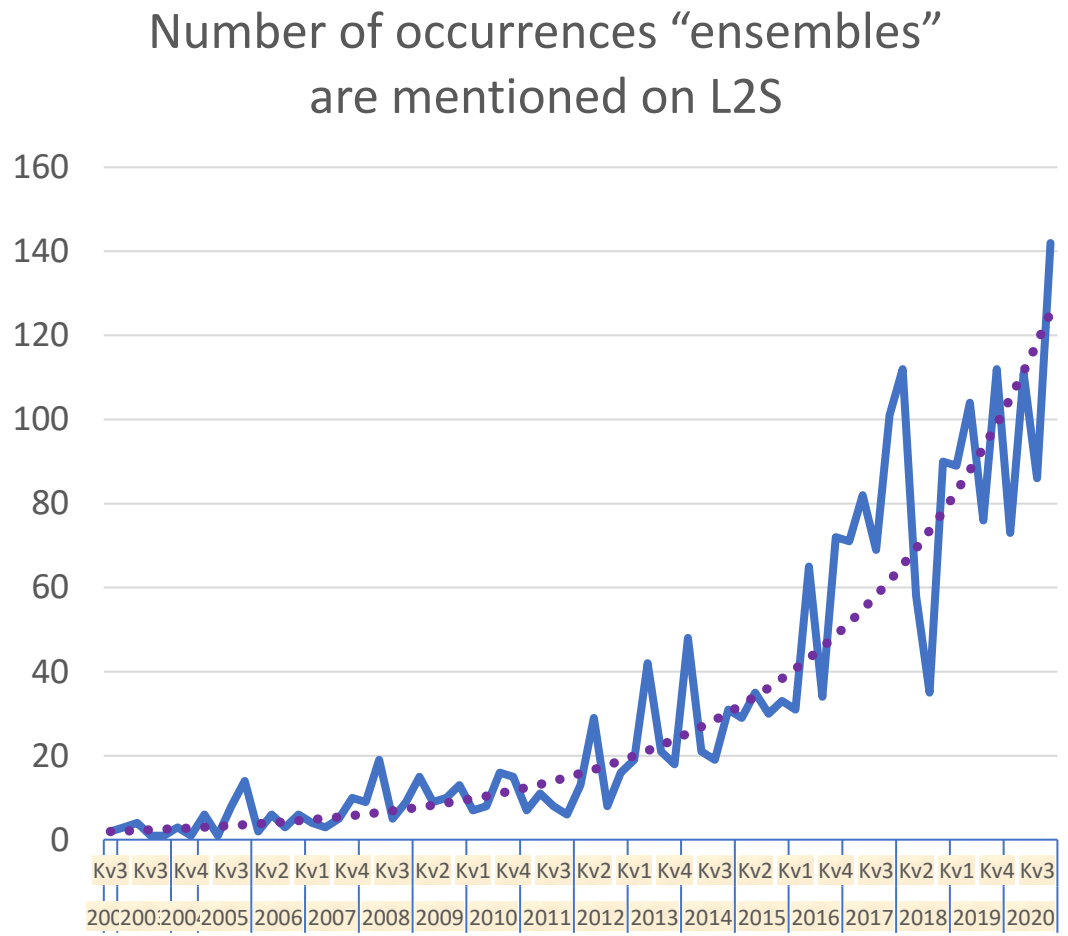
Are reserve forecasts any good?

Use of ensemble methods replacing deterministic reservoir modelling, thoughts from a geologist - Fridtjof Riis, NPD – Reservoir Characterization 2021 (NPF)

- Estimates well below 50 % of the PDO estimate are most common for small accumulations (<8 MSm3).
- Data quality and the evaluation methods are improving, but surprises still occur.
  - In the case of surprises, advanced statistical methods are of little help.
  - In such cases it may be better to prioritize deeper geological studies and plan for a development which can handle very different outcomes than to push the data into an ensemble model.
  - ! Take care if there are major data inconsistencies or very different interpretation possibilities.
- If the available data are representative for the subsurface, the ensemble methods are very useful.

Ensemble methods

- Improved analysis of uncertainty than what one / a few deterministic models can provide.
- Embedded workflows facilitate the updating of the model after new data are acquired
- Good for making rapid decisions when outcomes are within predicted range
- BUT - the tool only as good as the inputs and usability of the outputs



Blue line: Number of occurrences, Dots: exponential trend line

Need for agreement on “ensemble standards”

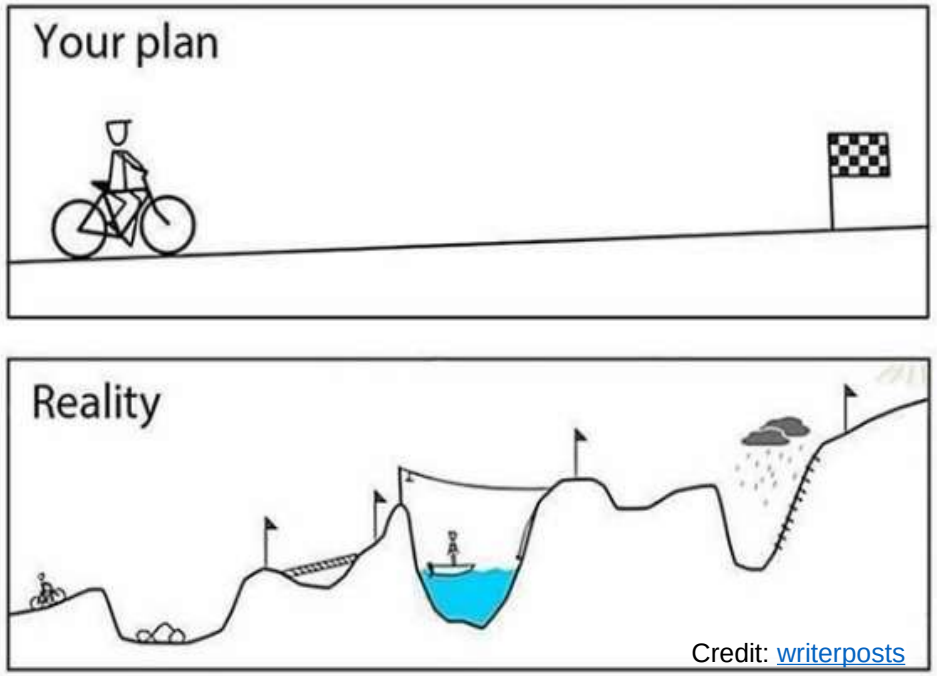
- Black box feeling
  - Maths and geology
  - Aggregated properties/profiles can be meaningless physically
  - Scenario evaluation/optimisation difficult
- “See-to-duty” can be problematic
  - What is shared varies from license to license
  - Digestibility of the data
  - Unable to run with own parameters (workflow sharing)

- Need for accepted guide on
  - Ensemble data sharing
  - Ensemble QC

- The guide needs to
  - Incorporate views from operators and partners
  - NPD can facilitate

Summary

- It is hard to make good decisions without an uncertainty centric approach
  - Uncertainty first, not last
- Probabilistic workflows improve decisions – if used correctly and in combination with other tools
  - Human behavioural challenges and software skills are key
  - Need an NCS guideline to enable good conversations / transparency



- How do we make sure we have a decent basis to state that the base estimate is the expected outcome and a P90/P10 is actually a P90/P10 ?

NORWEGIAN PETROLEUM DIRECTORATE

50 years

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Thank you for your attention!

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