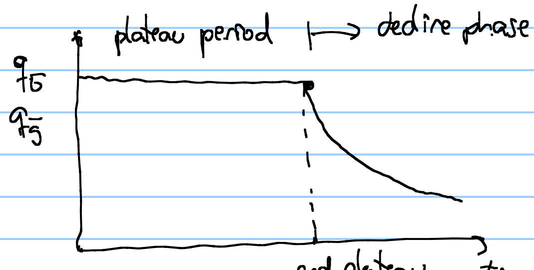
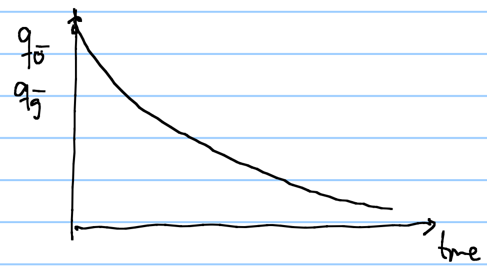
Field performance

- q_o, q_g vs. time

two ways to produce field

mode A (plateau mode) | mode B (decline mode)



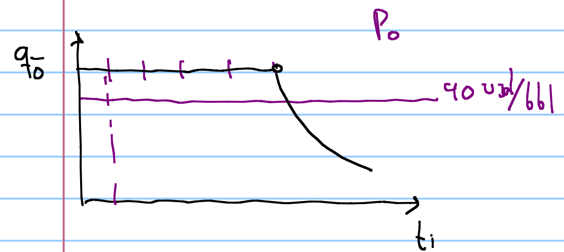


Review production data of fields in the Norwegian Continental shelf http://www.ipt.ntnu.no/~stanko/files/Files/20170402_NCS_Production_Data.xlsx

Production scheduling: deciding how much the field will produce with time
predicting " " " " " " " "

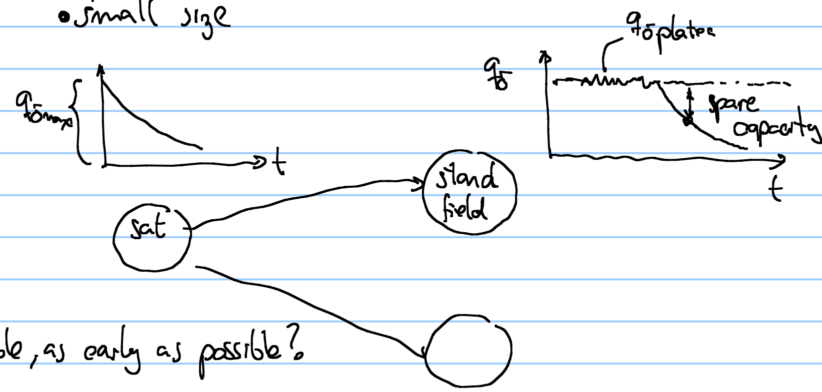
Mode A

- Standalone developments
- new fields
- need to develop whole infrastructure
- big - medium size



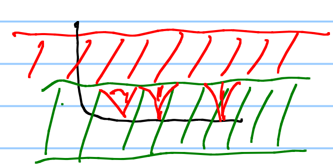
Mode B

- Satellite field
- Using existing facilities (from a neighbouring field)
- produce as much as possible, as early as possible
- small size



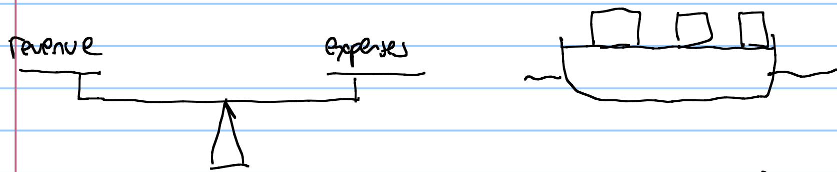
why not produce as much as possible, as early as possible?

- requirement from authorities to meet recovery factor



e.g. early gas coning might reduce recovery factor

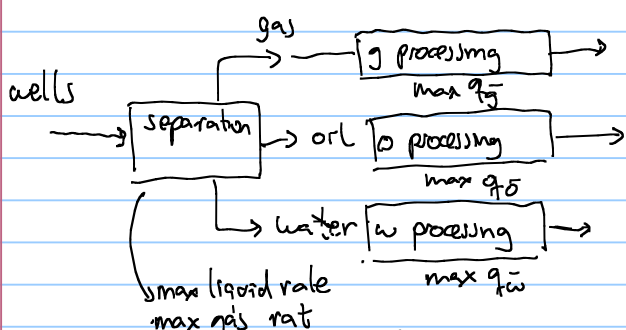
- ↑ plateau gives you higher revenue

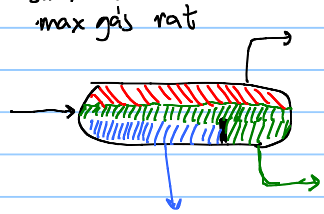


↑ plateau → bigger and higher capacity processing facilities
→ bigger offshore structure
→ more wells

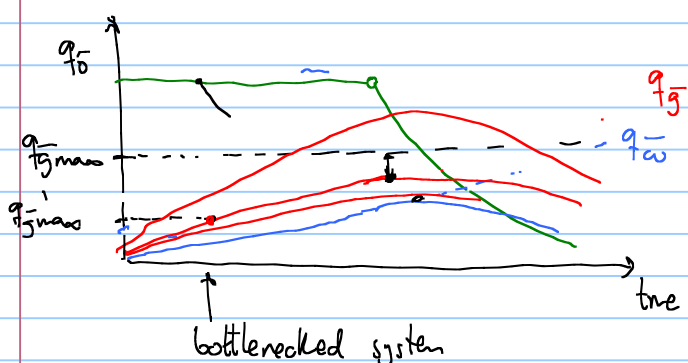
- Run sensitivity analysis on plateau height to define rate that maximizes economic value (NPV net present value)

- Plateau ends usually due to two reasons
  - system cannot produce more
  - reach a limit on the processing facilities

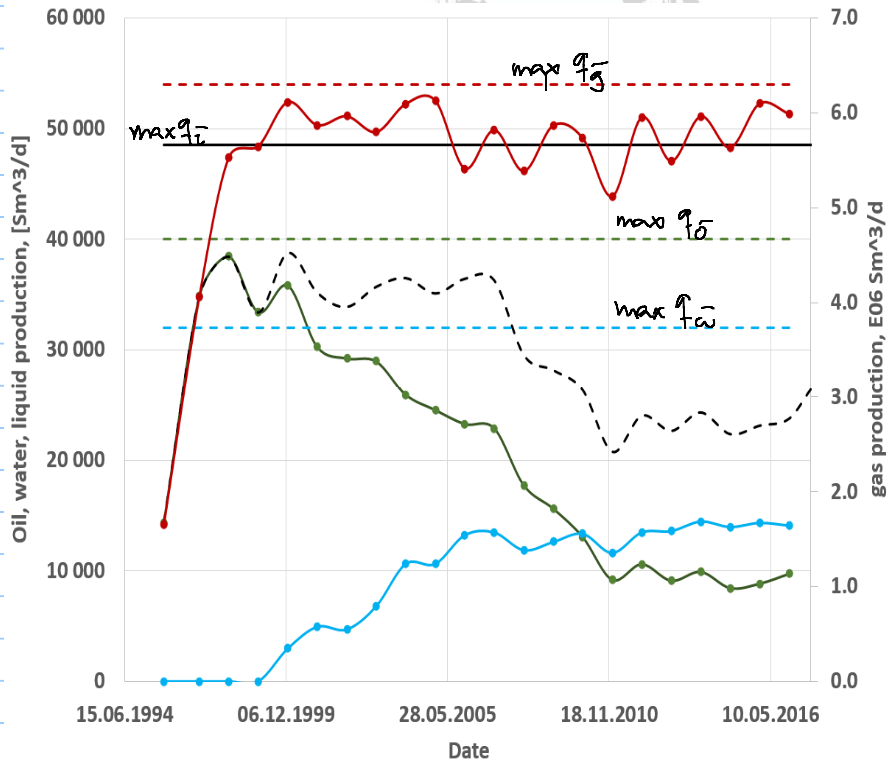




4 min



An example from Heidrun



Rule of thumb plateau rate for oil fields (1-5 years)

annual offtake of 0.1 (TRR) total recoverable reserves

$0.1 \cdot N_{pu}$

N initial oil in place

$N \cdot R_F = N_{pu}$ ultimate oil cumulative production

Goliat $N = 180\ E6$ stb ;

$RF = 30\%$

$N_{pu} = 54\ E6$ stb

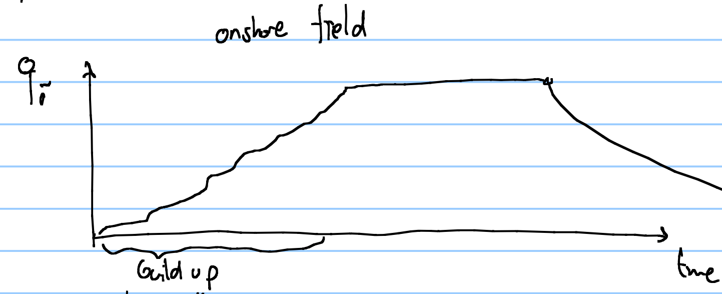
$54 \cdot E6 \cdot 0.1$ stb $= 5.4\ E6$ stb

$$q_{op} = \frac{5.4\ E6}{365} \approx 15000 \text{ stb/d}$$

uptime 90-95%

for gas fields (0.02-0.05) TRR plateau (10-30 years)

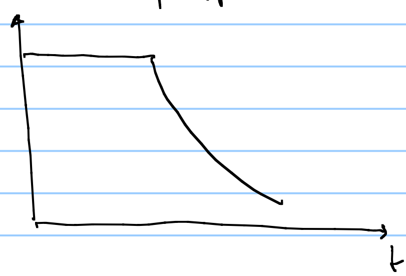
Onshore vs. offshore (page 4 of reference material)



build-up phase is short!
offshore – big investment to have offshore structure and processing facilities in place → to start producing

for onshore fields in remote locations the production profile is very similar to offshore fields!

no build up (pre-drilled wells)



gas vs. oil fields

oil
- easy to transport
- sold on market
- transportation by pipeline or tanker

gas
- need infrastructure (pipeline system)
- based on contracts / rate / time
  - penalty
  - swing factor

more information on page 9 (references)

- LNG liquified natural gas
  - LNG plant in field US$
  - LNG receiving terminal
  - Special tanker

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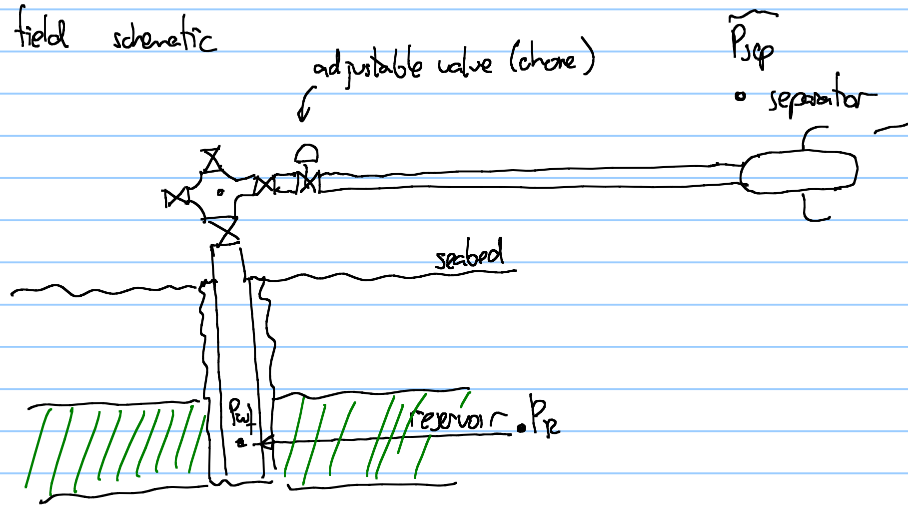
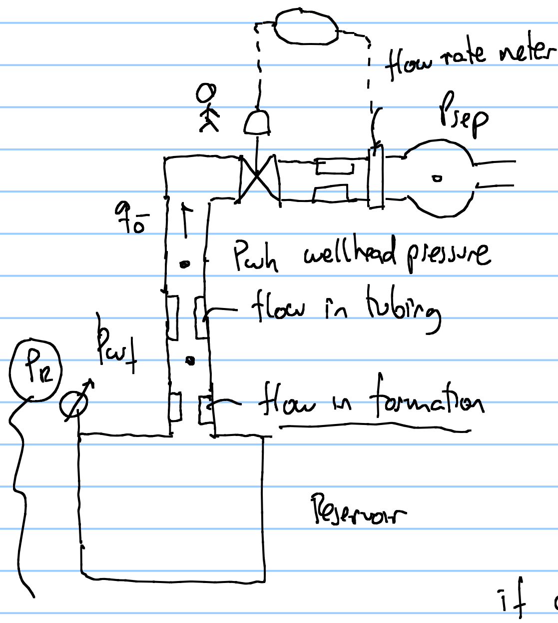
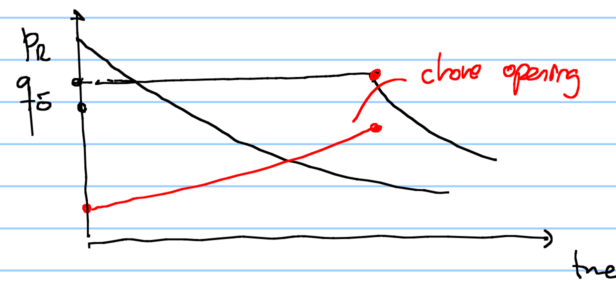
field schematic



Mechanical analogue of field

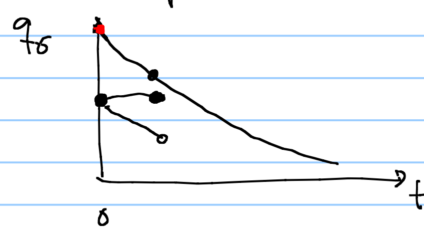


$q_o = f(P_R, P_{sep}, \text{choke opening})$



if choke is open

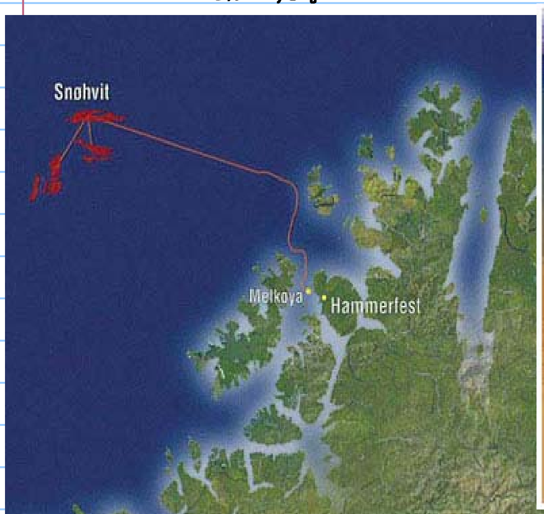
$q_o = (P_R, P_{sep}, \Delta p_{choke})$

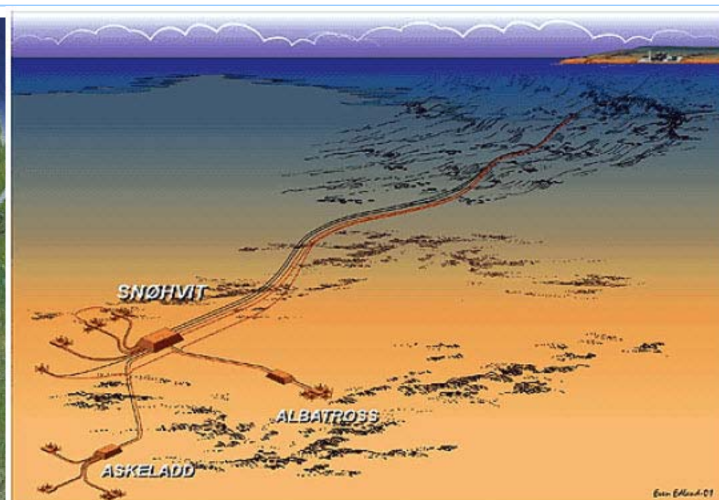


Produce your own field!

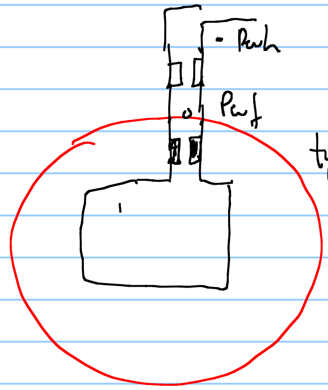
http://www.ipt.ntnu.no/~stanko/Field_Simulator.html

Class exercise:





- Neglect flow in wells, flowline, pipeline.
- Only using reservoir model



Estimate production profile and revenue of Snøhvit

typical Reservoir simulator : Eclipse
: CMG
Sensor

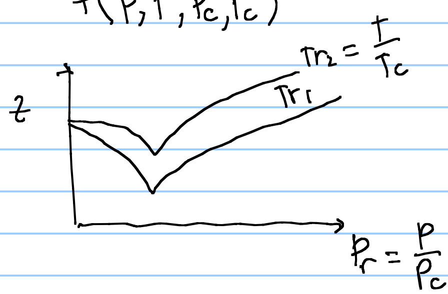
Model assumptions : homogeneous reservoir
high connectivity
all wells are identical
→ high permeability, transient is very short
Dry gas (no condensation)

$$P_R = \frac{P_i}{z_i} z_R \left(1 - \frac{G_p}{G}\right)$$

- P_R: reservoir pressure
- P_i: initial res pressure
- G_p: cumulative gas production
- G: initial gas in place
- z_i, z_R: deviation factor $f(p, T, P_c, T_c)$

$$G_p = \int_0^t q_g(t)\,dt$$

q_g in Sm^3/d, t in years

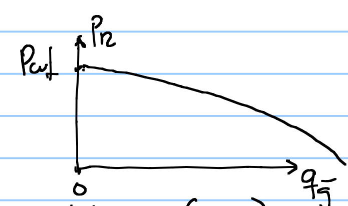


$$P_R = \frac{P_i}{z_i} z_R \left(1 - \frac{G_p}{G}\right)$$

$z_R = f(T_R, P_R)$, $z_i = f(T_R, P_i)$

Backpressure equation for Δp loss in formation

$$q_g = C\left(P_R^2 - P_{wf}^2\right)^n$$ Inflow performance relationship (IPR)

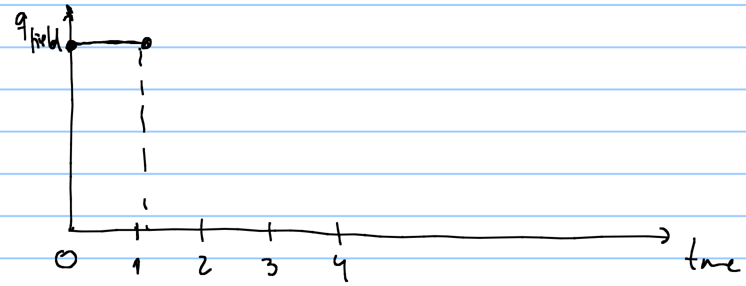


our control variable P_{wf}

? what is P_{wf} when choke is fully open?

define $P_{wf\,min} = 120$ bara

$$q_{field} = N_{wells} \cdot q_{we} = N_{wells}\, C\left(P_R^2 - P_{wf}^2\right)^n \quad 70\text{ E6 } Sm^3/d$$



assumption $Z \approx const$ $Z \approx 1$

Predicting production profile of Snohvit field - Reservoir simulator proxy - Milan Stanko, 20190111

Snohvit gas Field

G=IGIP	270E+09	Sm3
T_R	92	oC
P_i, initial Res pressure	276	bara
C, inflow Back pressure coefficient	1000	Sm3/bar^2n
n, backpressure, exponent	1	
Gas molecular weight (Methane)	16	kg/kmole
Gas specific gravity	0.55	Gas specific gravity
Number of wells	9	
P_{wfmin}	120	[bara]
q_{field_target}	2.00E+07	[Sm^3/d]
Gas price	0.11	[usd/Sm^3]
Discount rate	7	[%]
Field gas rate for abandonment	8.00E+06	[Sm^3/d]
Uptime	3.47E+02	d

time	qwell_pot	qfield_pot	qfield	pwf	ΔGp	Gp	Z	RF	PR	Revenue	DR	CDR
[years]	[Sm^3/d]	[Sm^3/d]	[Sm^3/d]	[bara]	[Sm^3]	[Sm^3]	[-]	[-]	[bara]	[USD]	[USD]	[USD]
0	6.18E+07	5.56E+08	2.00E+07			0.00E+00	1.000	0.000	276			
1	5.79E+07	5.21E+08	2.00E+07		6.94E+09	6.94E+09	1.000	0.026	269			
2	5.42E+07	4.87E+08	2.00E+07		6.94E+09	1.39E+10	1.000	0.051	262			
3	5.05E+07	4.54E+08	2.00E+07		6.94E+09	2.08E+10	1.000	0.077	255			
4	4.69E+07	4.22E+08	2.00E+07		6.94E+09	2.77E+10	1.000	0.103	248			
5	4.35E+07	3.91E+08	2.00E+07		6.94E+09	3.47E+10	1.000	0.128	241			
6	4.01E+07	3.61E+08	2.00E+07		6.94E+09	4.16E+10	1.000	0.154	233			
7	3.68E+07	3.32E+08	2.00E+07		6.94E+09	4.85E+10	1.000	0.180	226