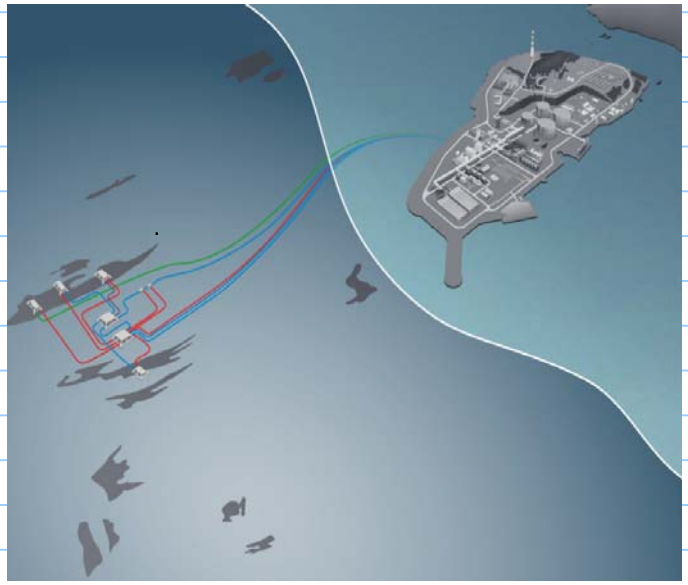
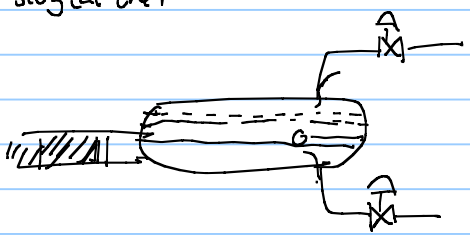
20180305 Production scheduling calculations for Snowhite field
Snøhvit

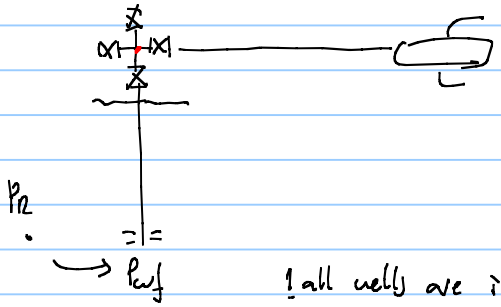
$q_{field} = 20$ E6 Sm^3/d for 20 years

(by contract)

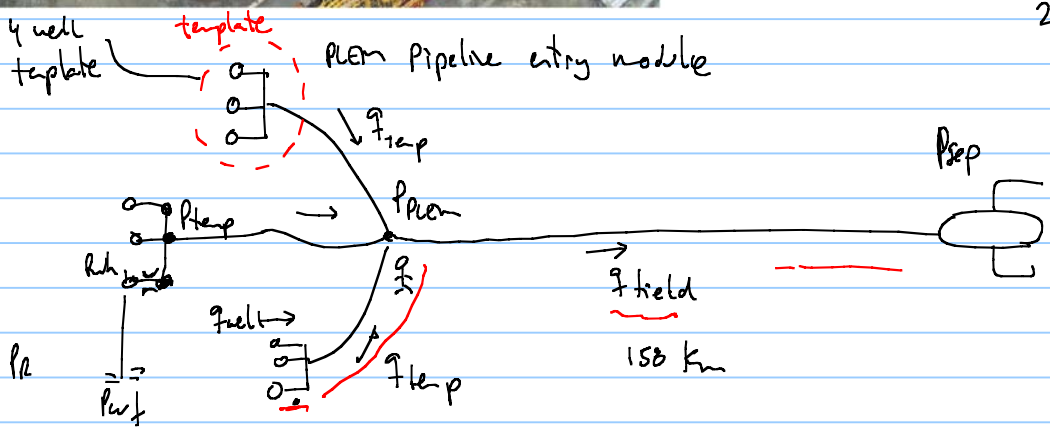


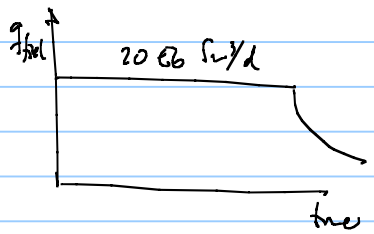
slug catcher





1: all wells are identical
2: the syste is symmetric
3: q_{well} is same
q_{temp} is sample

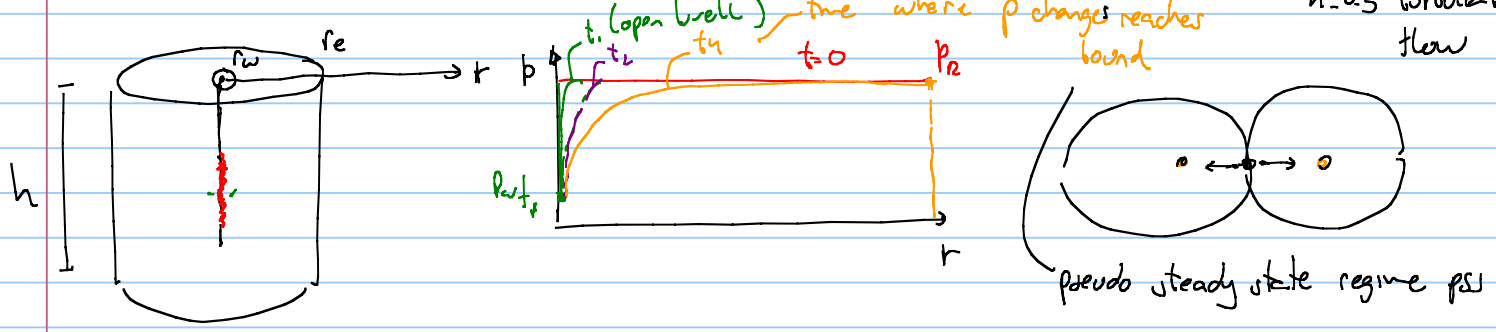




- Equilibrium point is choke
- Dry gas

Inflow performance relationship:

- Backpressure equation $q_{well} = C_R \left(\bar{p}_R^2 - p_{wf}^2\right)^n$ is valid for low pressures (100 bara >)
  - n accounts for non-Darcy flow; $n=1$ Darcy flow, $n=0.5$ turbulent flow



the backpressure equation is derived by applying Darcy law on radial homogeneous single well geometry

$$q_{sc} = \frac{2\pi k h}{\left[\ln\left(\frac{r_e}{r_w}\right) - 0.75 + S + DQ\right]} \frac{T_{sc}}{p_{sc} T_R} \int_{p_{wf}}^{\bar{p}_R} \frac{p}{\mu z} dp$$

- Dry gas tubing equation (derivation in page 164 of compendium)

$$q_{well} = C_T \left(\frac{p_{wf}^2}{e^S} - p_2^2\right)^{0.5} \qquad S = \frac{28.97 \cdot \gamma_g \cdot g \cdot H}{z_{av} \cdot R \cdot T_{av}}$$

H: height difference between wf and wh

$$C_T = \frac{\pi}{4} \cdot \left(\frac{R}{M_{air}}\right)^{0.5} \left(\frac{T_{sc}}{p_{sc}}\right) \left[\frac{D^5}{\gamma_g \cdot f_m \cdot z_{av} T_{av} \cdot L}\right]^{0.5} \left[\frac{S e^S}{e^S - 1}\right]^{0.5}$$

$$T_{av} = \frac{T_{wh} + T_{wf}}{2}$$

- flowline and pipeline → 1= horizontal pipe

$$q_{sc} = C_{FL} \left(p_{in}^2 - p_{out}^2\right)^{0.5}$$

$$q_{Temp} = C_{FL} \left(p_{Temp}^2 - p_{Plow}^2\right)^{0.5}$$

$$q_{field} = C_{FL} \left(p_{Plow}^2 - p_{Sep}^2\right)^{0.5}$$

Solve system of equations:

$$q_{fw} = C_R \left(P_R^2 - P_{wf}^2\right)^n$$ 2 unknown

$$q_{fw} = C_T \left(\frac{P_{wf}^2}{e^s} - P_{wh}^2\right)^{0.5}$$ 1 add. unknown

$q_{Temp} = 3 \cdot q_{fw}$

$$q_{Temp} = C_{FL} \left(P_{Tem}^2 - P_{PLem}^2\right)^{0.5}$$ 2 add unknowns

$$q_{field} = C_{PL} \left(P_{PLem}^2 - P_{Sep}^2\right)^{0.5}$$

4 equations. 5 unknowns

if calculation natural equ ⇝ for open choke $P_{wh} = P_{Temp}$ 5 eq, 5 unk.

plateau calculations ⇝ $q_{field} = 20E6\ Sm^3/d$ 4 eq, 4 unk

Snohvit Gas Field, Ex. Set 2, Prob. 3. TPG4230, Prof. Milan Stanko

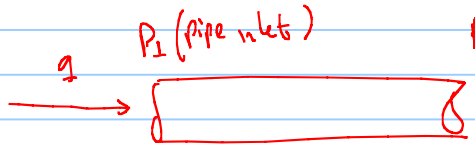
G=IGIP	270E+09	Sm3
Annual production rate	0.027	fraction of IGIP
Production days per year	365	day
T_R	92	oC
Pi, initial Res pressure	276	bara
C, inflow Back pressure coefficient	1000	Sm3/bar^2n
n, backpressure, exponent	1	
Ct, Tubing coefficient (2100 MDx0.15	4.03E+04	Sm3/bar
Elevation coeff, S	0.155	
$C_{FL\,Flowline}$ Template-PLEM (5000x0..	2.83E+05	Sm3/bar
$C_{PL\,Pipeline}$ PLEM-Shore (158600x0.6	2.75E+05	Sm3/bar
Separator (slug catcher) pressure	30	bara
Gas molecular weight (Methane)	16	kg/kmole
Gas specific gravity	0.55	Gas specific gravity
Gas density at Sc	0.67	kg/m^3
Number of templates	3	
Number of wells	9	
Desired plateau	20	years
qfield	20.0E+6	[Sm^3/d]

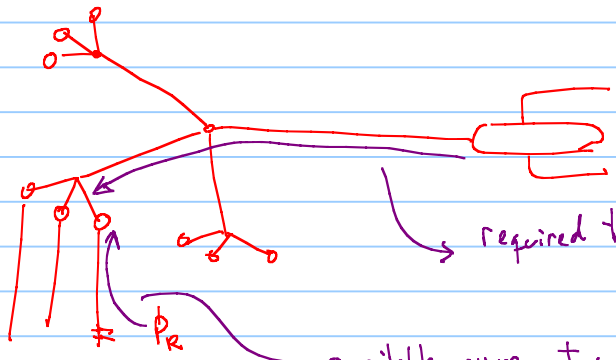
1. Identical wells
i.e same PR CR, n, Ct, S
2. System is symmetric
3. Field Rate = 20 MMSCM
qwell = qg/no.of.wells
PR= ZR* P/Zi * (1-Gp/G)
Pwf = sqrt(Pr^2-qg/C) as n=1
Pwh = sqrt((pwf^2/e^s)-((qg/Ct)^2))
Psep
Pplem
Ptempl

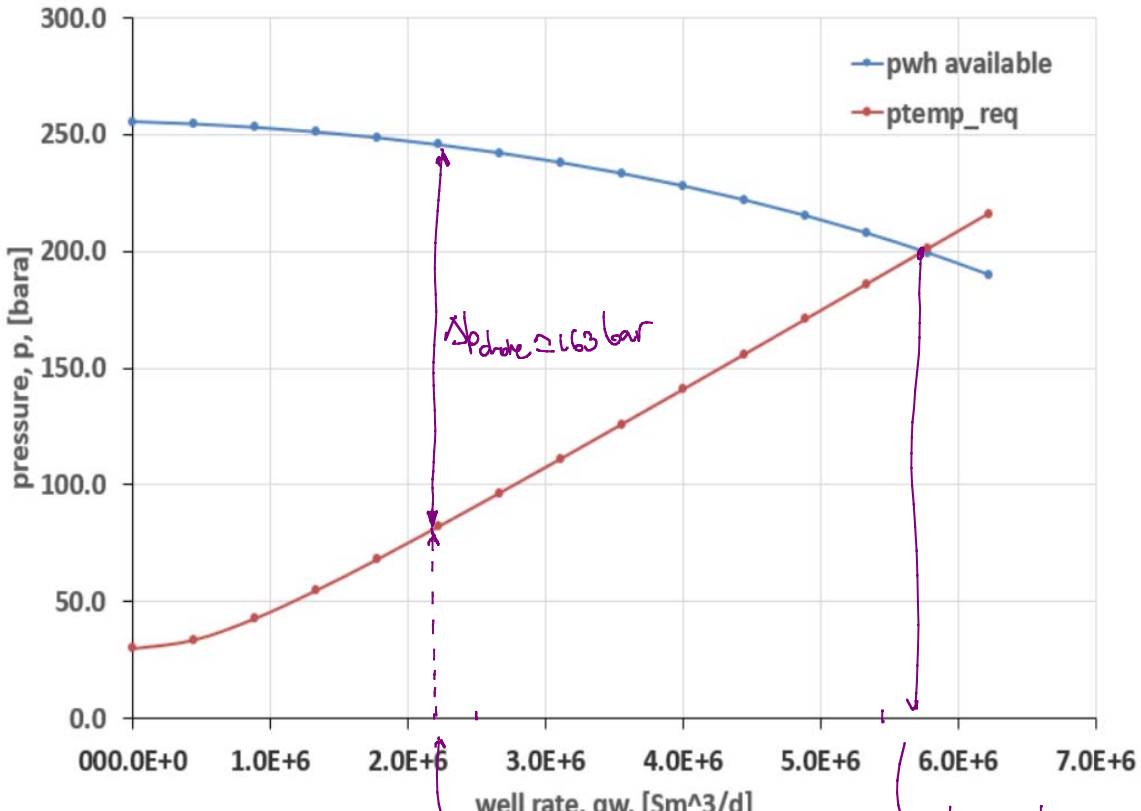
IPR solve Pwf — TPR solve P_2 — line eq solve P_1 — line eq. solve P_1

for each well

qfield	Gp	Z	PR	qwell	Pwf	Pwh avail	Ptemp req	Pplem req	Psep	qtemp	DeltaPchoke
[Sm^3/d]	[Sm^3]	[-]	[bara]	[Sm^3/d]	[bara]	[bara]	[bara]	[bara]	[bara]	[Sm^3/d]	[bara]
20.0E+6			276	2.2E+6	271.9	245.5	82.1	78.7	30.0	6.7E+6	163

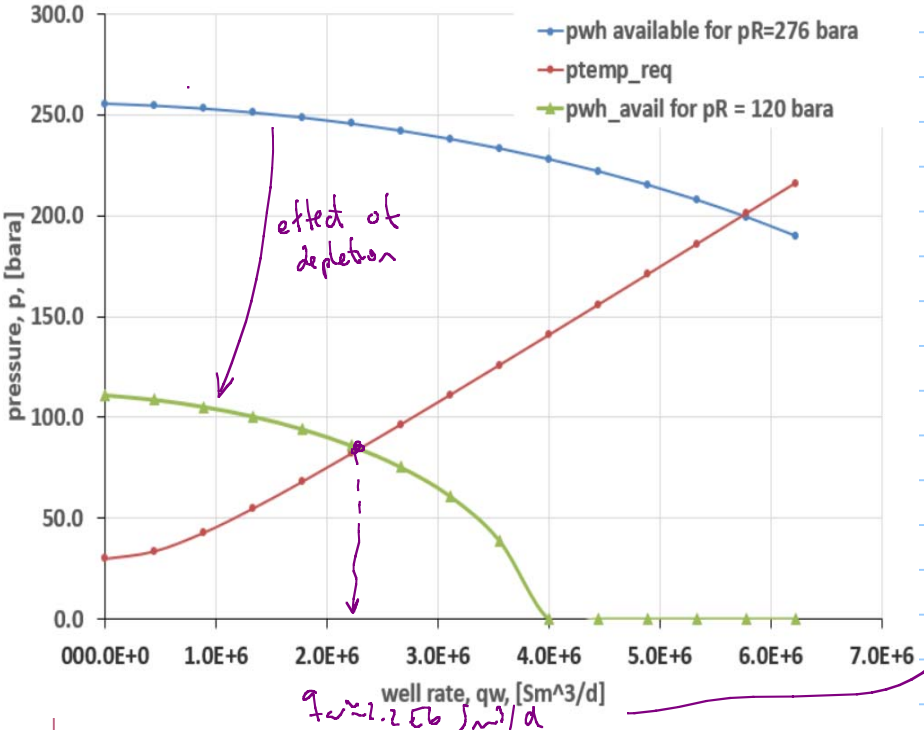






plateau rate $q_w = \frac{20\,E6}{q} = 7.2\,E6\ Sm^3/d$

if no choke $q_{well} \simeq 5.75\,E6\ Sm^3/d$



the end of plateau will be (approx.) when $p_R \simeq 120$ bara