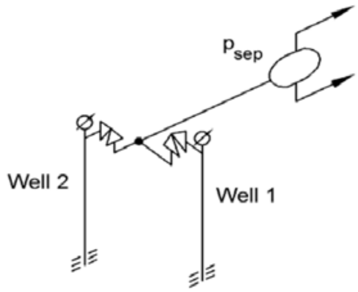
Youtube video: Solving dry gas networks in Excel

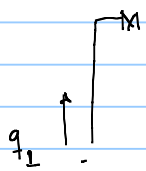
Exercise: using data from Problem 4 of the Exam 2017:

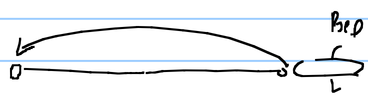
PROBLEM 4 (18 POINTS). Network solving.

Consider the gas field with two wells, a manifold a pipeline and a separator shown in the figure below. The wellhead of the wells are very close to the junction so it can be safely assumed that the wellhead pressure and junction pressure are equal when the choke is open.



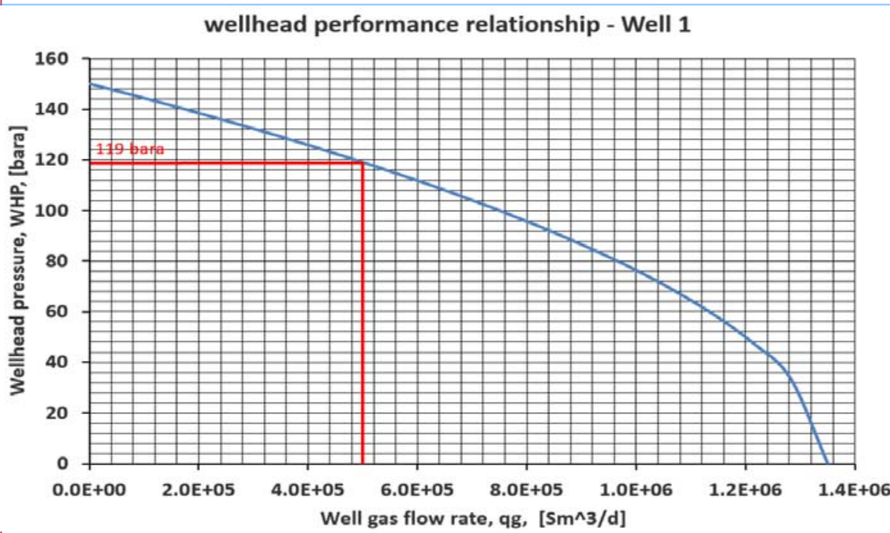
Will it be possible to produce 0.5 E06 Sm3/d from each well? if so, what is the choke deltap required in each well?

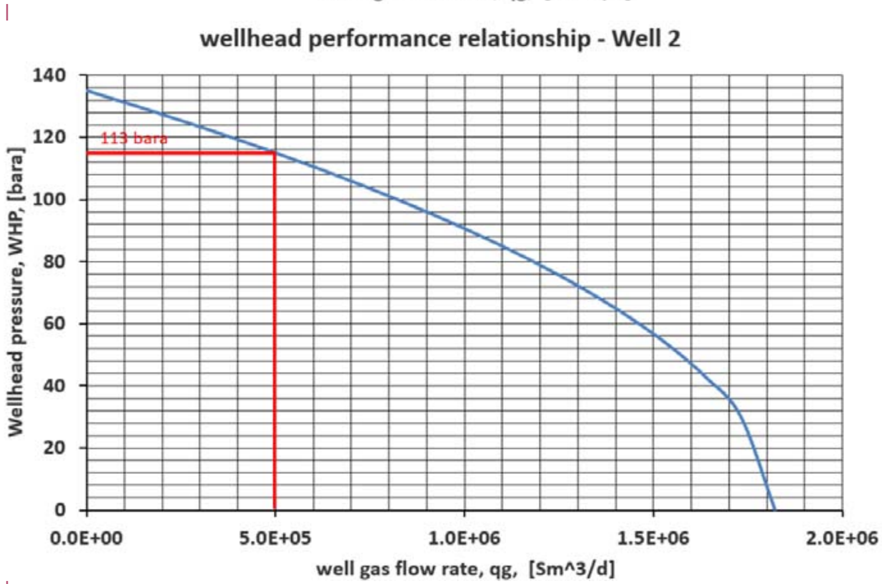


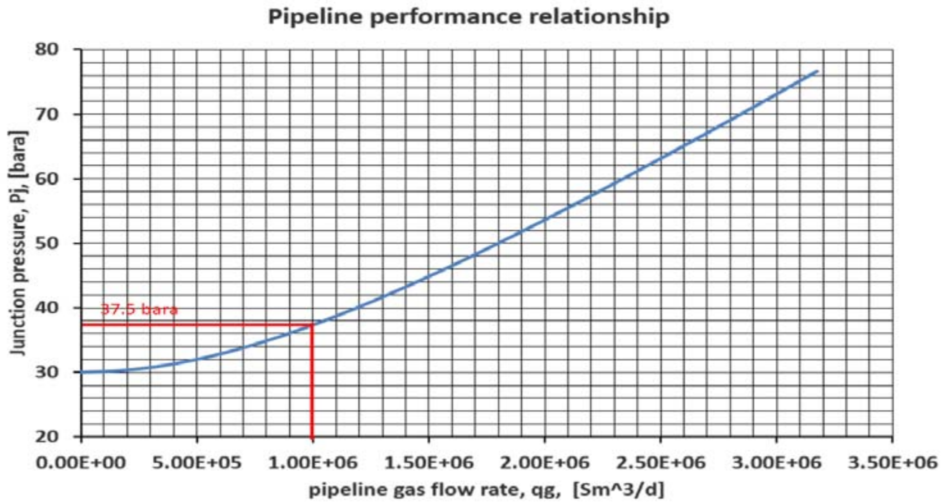


verify $\Delta p > 0$ then q_1 is feasible

if $\Delta p < 0$ then q_1 is no feasible



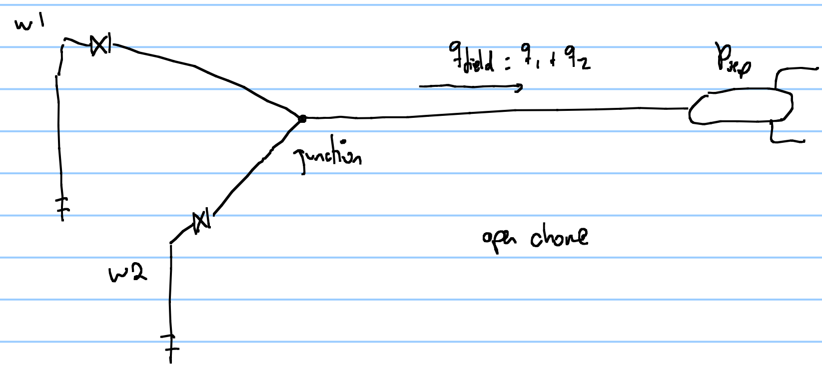




Deltap_choke1 = 119 - 37.5 = 81.5 bara
Deltap_choke2= 113-37.5 = 75.5 bara

Yes, it is possible to produce 0.5 E06 Sm3/d from well 1 and 2.

Exercise on Dry gas network using Excel



we have to assume either $\bar{q}_1$, $\bar{q}_2$

OR: P_{wf_1}, P_{wf_2} ← $P_{wf} < P_R$

↳ we prefer to assume P_{wf} because I know the upper bound

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

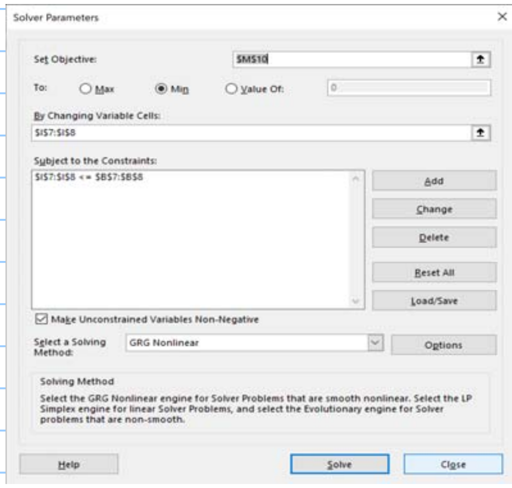
$$P_{wf} = \sqrt{P_R^2 - \left(\frac{q}{C_R}\right)^{1/n}}$$

i don't know q_{max}, and can give problems in eq.

objective variable:

$$\left(P_{j_{av}} - P_{j_1}\right)^2 + \left(P_{j_{av}} - P_{j_2}\right)^2 + \left(P_{j_{av}} - P_{j_{sep}}\right)^2$$

		IPR		Tubing		Flowline						
Component Name	p_R	C	n	S	Ct	Cfl	psep	pwf	qwell	pwh	pjunc	error
	[bara]	[Sm^3/bar^2n]			[Sm^3/bar^2]	[Sm^3/bar^2]	[bara]	[bara]	[Sm^3/d]	[bara]	[bara]	(bara^2)
W_1	120	52	0.8	0.13	7680	8673		38	1.02E+05	33	31	1E-0
W_2	120	40	0.75	0.11	8600	7563		34	4.95E+04	31	31	9E-1
Pipeline						14080	28.6		1.51E+05		31	2E-0
										Average=	31	4E-0


Solver Parameters

Set Objective: $M$10

To: Max / Min / Value Of: 0

By Changing Variable Cells: $I$7:$I$8

Subject to the Constraints:
$I$7:$I$8 <= $B$7:$B$8

Add / Change / Delete / Reset All / Load/Save

Make Unconstrained Variables Non-Negative

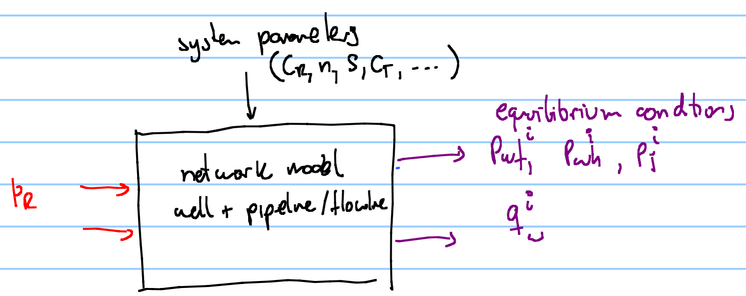
Select a Solving Method: GRG Nonlinear — Options

Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Help / Solve / Close

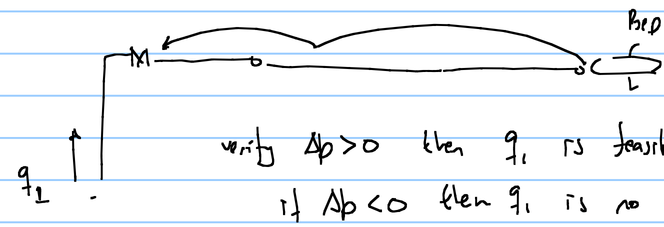
If solver is not available

Activate solver → excel menu → options
↓
Add in
↓
"go"
↓
tick on "solver"
or "problem(solver)"



solving the network
with choke

- option 1, fixing rates
(option usually not available in commercial software)



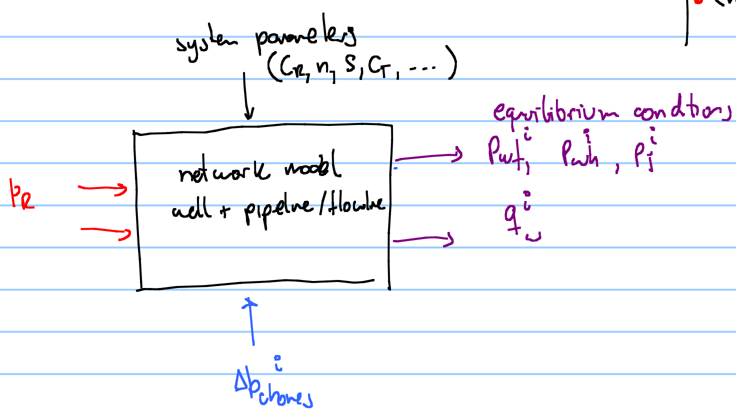
verify $\Delta p > 0$ then q_1 is feasible
if $\Delta p < 0$ then q_1 is no feasible

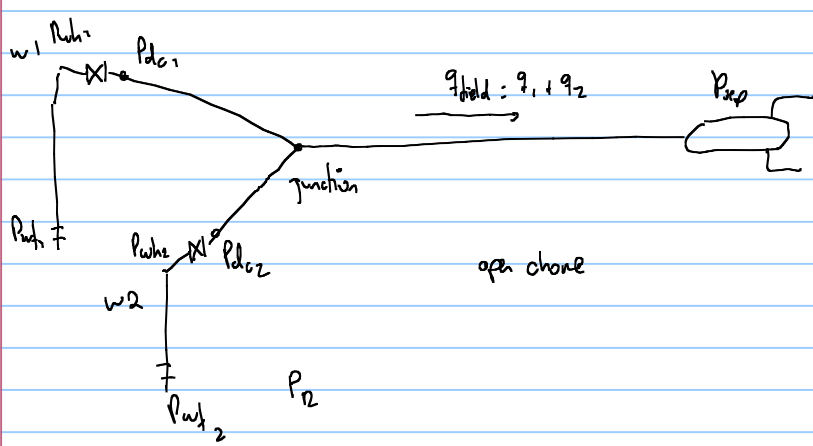
for example, it is desirable to produce

$$\begin{cases} q_1 = 80000 \ Sm^3/d \\ q_2 = 40000 \ Sm^3/d \end{cases}$$

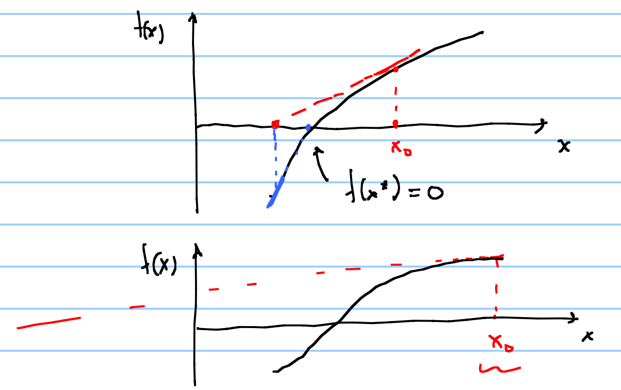
		IPR			Tubing	Flowline							
Component Name	p_R	C	n	S	Ct	Cfl	psep	pwf	qwell	pwh	dpchoke	pdc	pjunc
	[bara]	[Sm^3/bar^2n]			[Sm^3/bar^2]	[Sm^3/bar^2]	[bara]	[bara]	[Sm^3/d]	[bara]	[bar]	[bar]	[bara]
W_1	120	52	0.8	0.13	7680	8673		69	8.00E+04	64	33	31	30
W_2	120	40	0.75	0.11	8600	7563		66	4.00E+04	63	32	30	30
Pipeline						14080	28.6		1.20E+05				30

- option 2 : include the choke "model" → 2 options
  - Δp_{choke} ← this option will be discussed next
  - choke opening $\Delta p_{choke} = f(q_g, \text{Opening}, p_1)$





	IPR			Tubing	Flowline								
p_R	C	n	S	Ct	Cfl	psep	pwf	qwell	pwh	dpchoke	pdc	pjunc	error
[bara]	[Sm^3/bar^2n]			[Sm^3/bar^2]	[Sm^3/bar^2]	[bara]	[bara]	[Sm^3/d]	[bara]	[bar]	[bar]	[bara]	(bara^2)
120	52	0.8	0.13	7680	8673		42	9.92E+04	38	5	33	30	3E-10
120	40	0.75	0.11	8600	7563		39	4.84E+04	36	5	31	30	1E-09
					14080	28.6		1.48E+05				30	3E-09
									Average=			30	4E-09

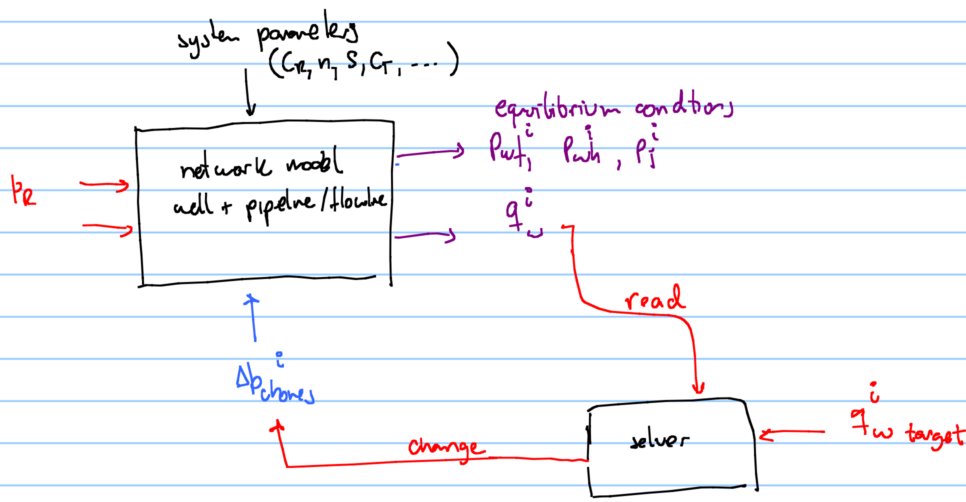


-- step 1
--- step 2

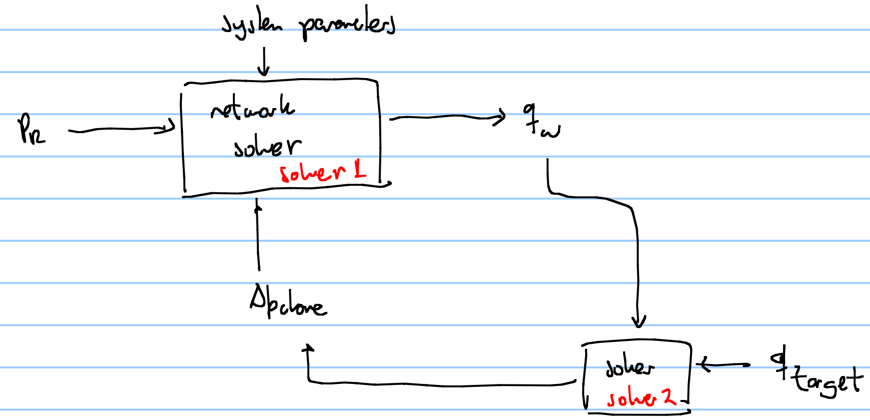
for derivative based solver it is necessary to give a good initial seed

	IPR			Tubing	Flowline								
p_R	C	n	S	Ct	Cfl	psep	pwf	qwell	pwh	dpchoke	pdc	pjunc	error
[bara]	[Sm^3/bar^2n]			[Sm^3/bar^2]	[Sm^3/bar^2]	[bara]	[bara]	[Sm^3/d]	[bara]	[bar]	[bar]	[bara]	(bara^2)
120	52	0.8	0.13	7680	8673		57	9.01E+04	52	20	32	30	1E-09
120	40	0.75	0.11	8600	7563		54	4.44E+04	51	20	31	30	8E-10
					14080	28.6		1.35E+05				30	4E-09
									Average=			30	6E-09

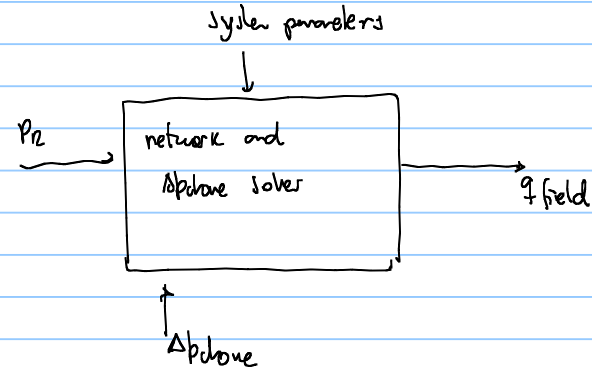
- How to use this model to find Δp_{choke} such that $q_1 = 80000\ Sm^3/d$, $q_2 = 40000\ Sm^3/d$



in excel it is not possible to have two levels of solver



"Merging the two solvers"

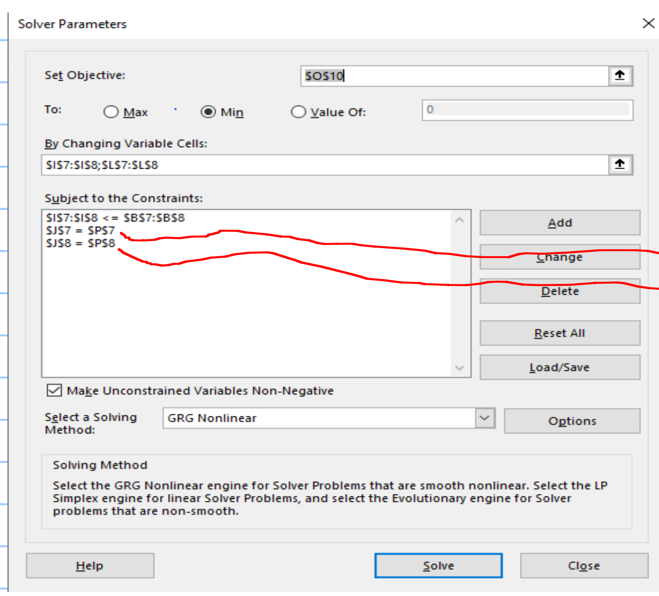


objective variable:

$$\left(P_{j_{av}} - P_{j_1}\right)^2 + \left(P_{j_{av}} - P_{j_2}\right)^2 + \left(P_{j_{av}} - P_{j_{sep}}\right)^2$$

variables

changing P_{wf_1}, P_{wf_2}, $\Delta p_{choke\,1}$, $\Delta p_{choke\,2}$



constraints

$q_1 = q_{1\,target}$

$q_2 = q_{2\,target}$

	IPR			Tubing	Flowline									
p_R	C	n	S	Ct	Cfl	psep	pwf	qwell	pwh	dpchoke	pdc	pjunc	error	qtarget
[bara]	[Sm^3/bar^2n]			[Sm^3/bar^2]	[Sm^3/bar^2]	[bara]	[bara]	[Sm^3/d]	[bara]	[bar]	[bar]	[bara]	(bara^2)	[Sm3/d]
120	52	0.8	0.13	7680	8673		69	8.00E+04	64	33	31	30	9E-11	80000
120	40	0.75	0.11	8600	7563		87	3.00E+04	82	52	30	30	5E-11	30000
					14080	28.6		1.10E+05				30	7E-12	
									Average=			30	2E-10	