1. Snohvit subsea gas well modeling in Prosper

Fluid information:

Use the black oil model for your PVT behavior.

WGR = 0 Sm^3/Sm3
CGR = 0 Sm^3/Sm^3
Condensate density = 751 Kg/m3
Gas gravity = 0.55
Formation Water salinity = 0 ppm
No H2S, CO2, N2.

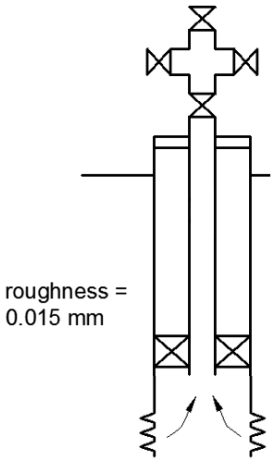
Well layout:

Deviation survey

MD [m]	TVD [m]
0	0
2100	2100

Geothermal gradient

MD [m]	T [C]
0	4
2100	92



Flow in tubing, tubing diameter 0.15 m

Overall wellbore heat transfer coefficient = 45 W/m^2 K

Reservoir info:

Producing from a single layer
Reservoir pressure = 276 bara
Reservoir temperature = 92 C
Backpressure coefficient = 1000 Sm^3/d/bara
Backpressure exponent = 1

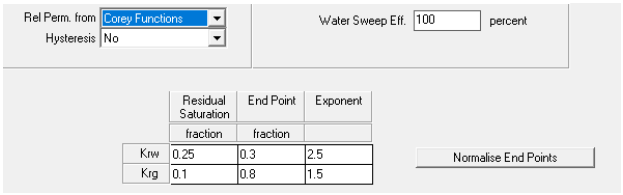
Tasks:

- Set up a prosper model of a subsea oil well.
- Estimate the producing rate using flow equilibrium assuming that the well is producing against a constant wellhead pressure of 100 bara
- Generate and export lift curves to be used in GAP (in the following exercise). p_{wh} range: 30-276 bara

1. Creating MBAL file of Snohvit reservoir

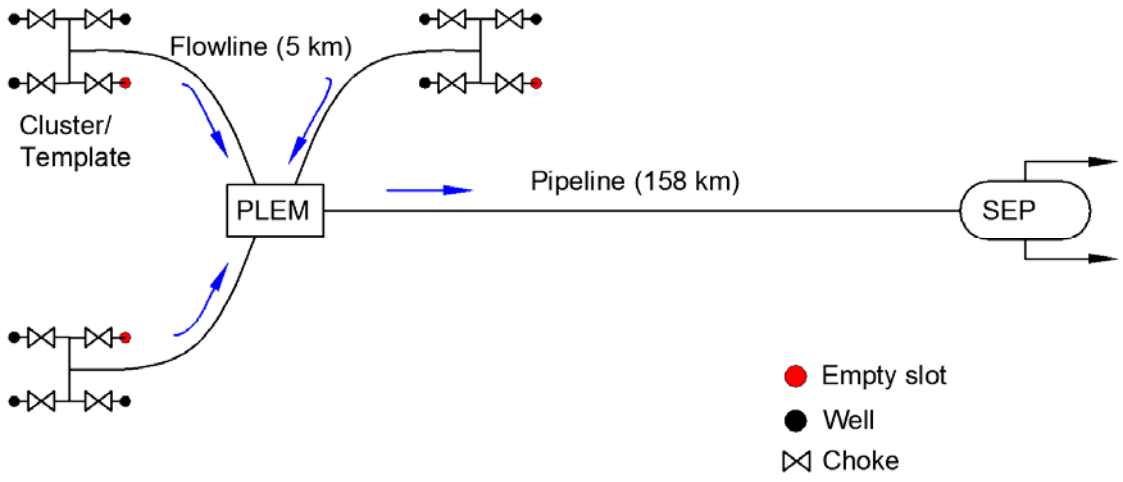
Fluid information:

Use the black oil model to represent your PVT behavior.
Gas gravity = 0.55
Condensate gravity = 751 Kg/m^3
At initial conditions no water.
Formation Water salinity = 0 ppm
No H2S, CO2, N2.
Temperature: 92 C
Initial pressure: 276 bara
Porosity: 0.15
Connate water saturation: 0.25
Original oil in place: 270 000 E6 Sm^3
Start of production: 10.02.2020
Water influx: No aquifer
Rel Perm: Corey Functions



2. Modeling of a subsea network with nine gas wells in GAP

The layout of the production network layout is shown below.



All wells are identical
Pipeline and flowline heat transfer coefficient: 5 W/m2 K
Pipeline ID: 0.680 m, roughness 1.5e-5 m
Flowline ID: 0.355 m, roughness 1.5e-5 m

Tasks:

- Build the GAP model of three subsea wells producing to the LNG plan in Melkøya.
- Adding a rate constraint to the separator of 20E06 Sm3/d, and run an “optimization”.
- Run in prediction mode to find field rate with time.

NTNU

Kunnskap for en bedre verden

Introduction to PETEX

10 February 2020

Prepared by:
- Agung Gedde Angga
- Milan Stanko
- Salma Alkindira

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NTNU

Outline

- Licensing
- PROSPER
- MBAL
- GAP: Set up Production Network
- GAP: Solve Production Network

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Outline

- Licensing
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- GAP: Set up Production Network
- GAP: Solve Production Network

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Licensing

-only 10 licenses are available
-please work in groups (9)

4

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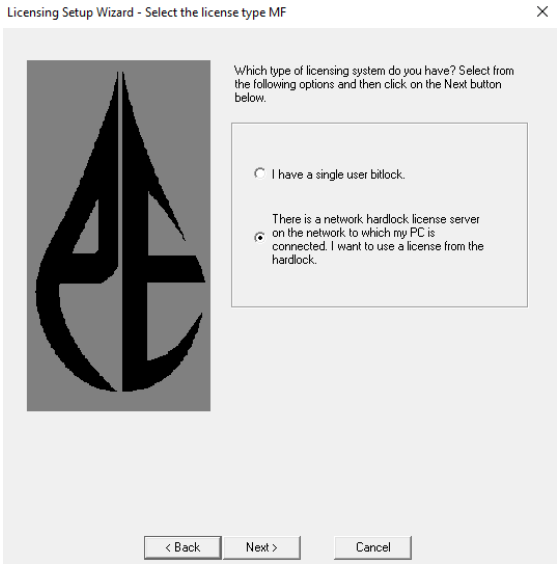
Licensing

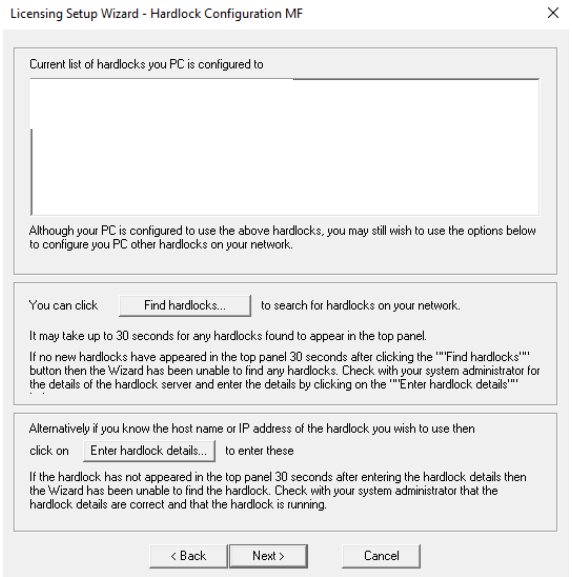


-only 10 licenses are available
-please work in groups (9)

5

5

Licensing

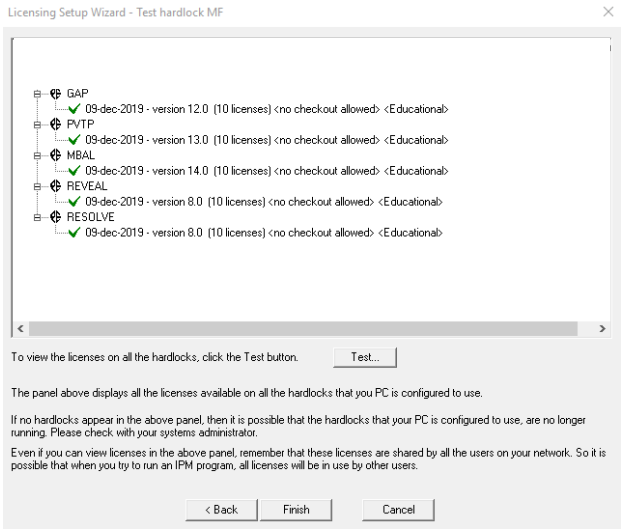


-only 10 licenses are available
-please work in groups (9)

6

6

Licensing



-only 10 licenses are available
-please work in groups (9)

7

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Outline

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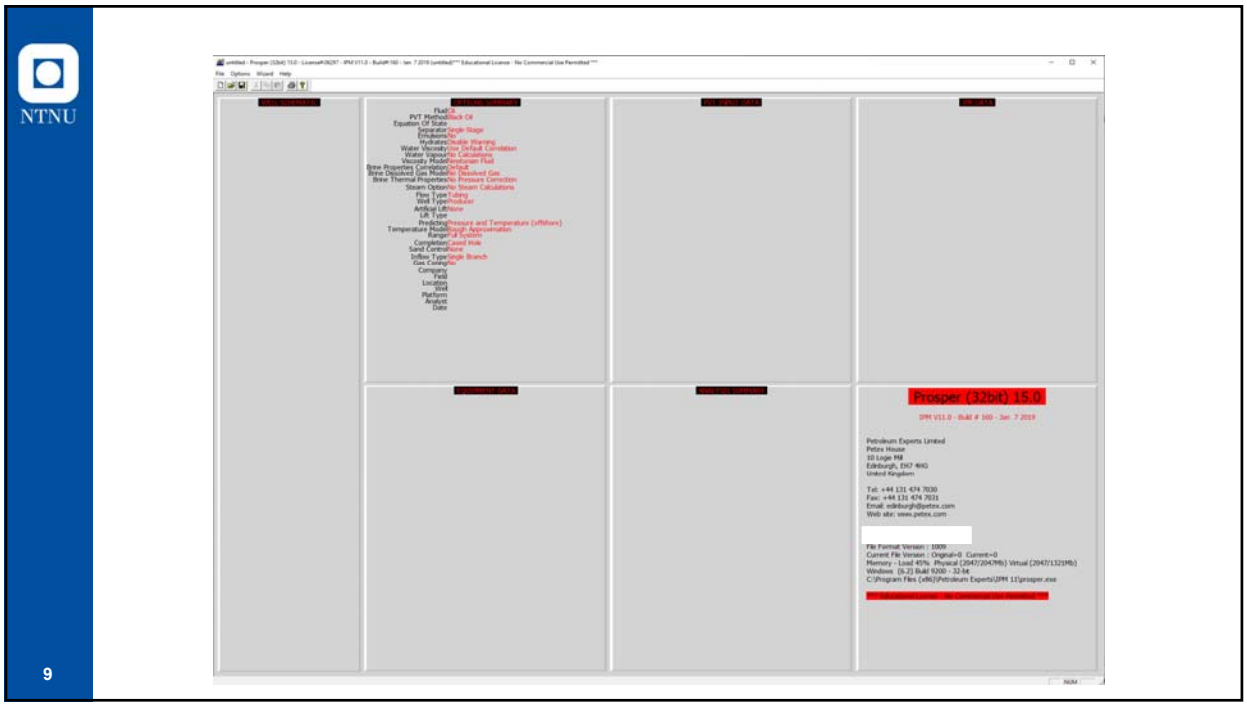
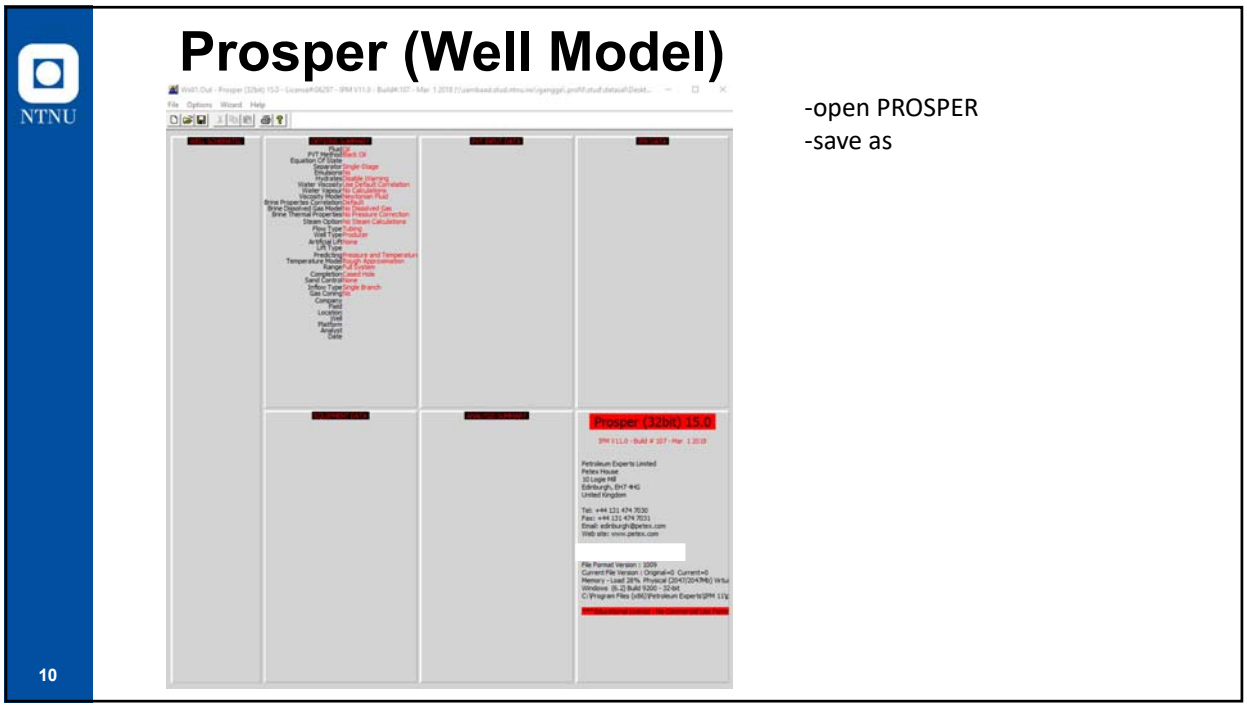
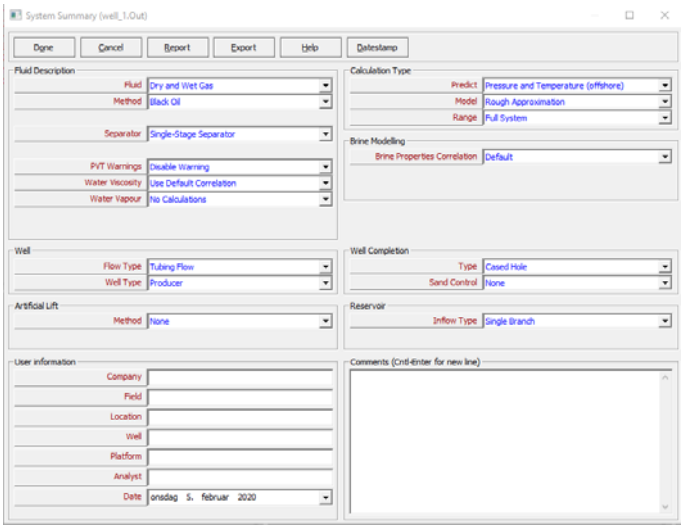

Prosper (32bit) 15.0
9

9


Prosper (Well Model)
-open PROSPER
-save as
Prosper (32bit) 15.0
10

10

Prosper – System Summary



-use default setting
-Fluid: dry and wet gas
-Method: Black Oil
-change unit system to Norwegian S.I.

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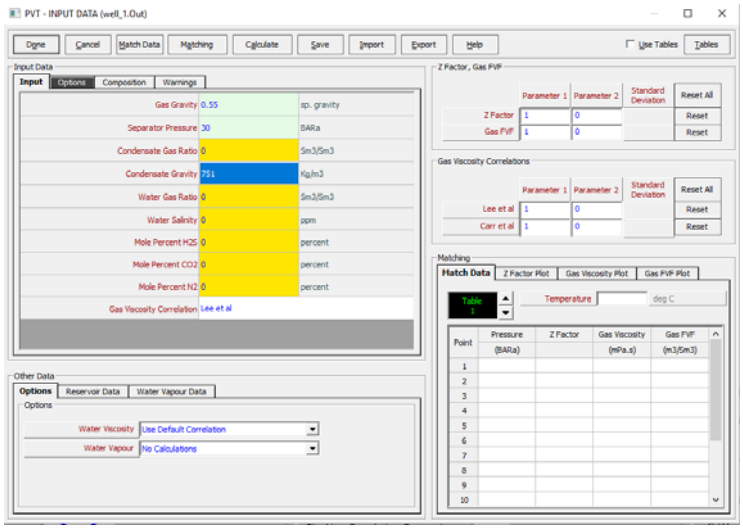
Prosper – PVT Input Data



-input PVT data (gas gravity, psep, condensate gravity)
-choose PVT correlation

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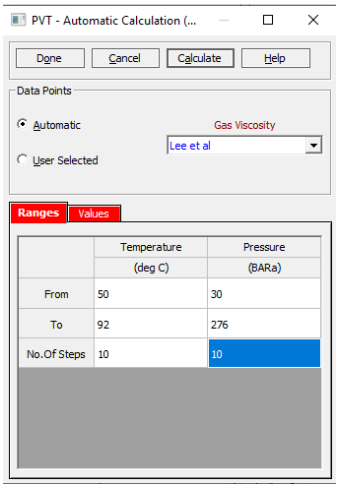
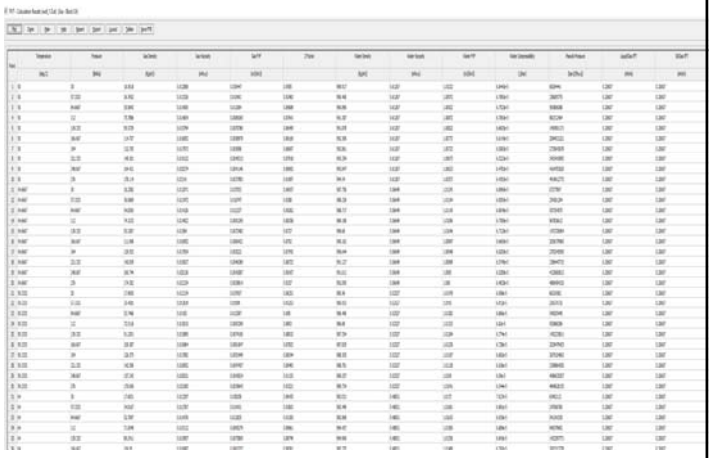
Prosper – PVT Input Data

-calculate PVT properties
-input Tres & Pres





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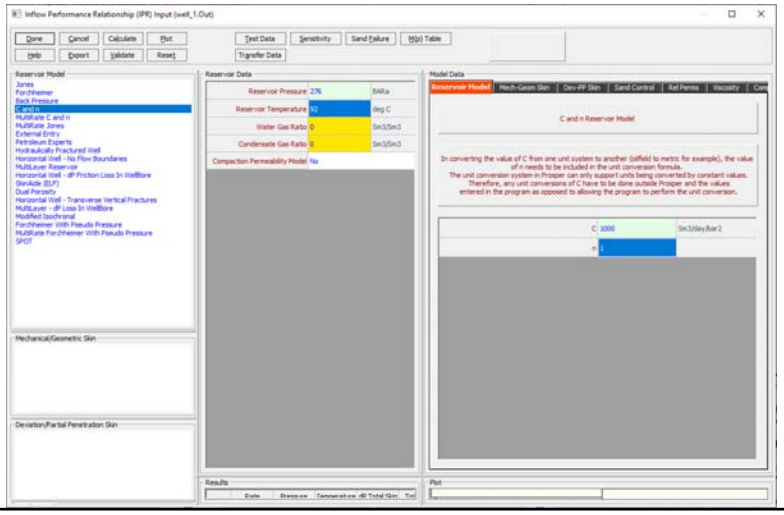
Prosper – IPR Data

-Reservoir model: C and n
-input reservoir data (Pres, Tres, C, n)



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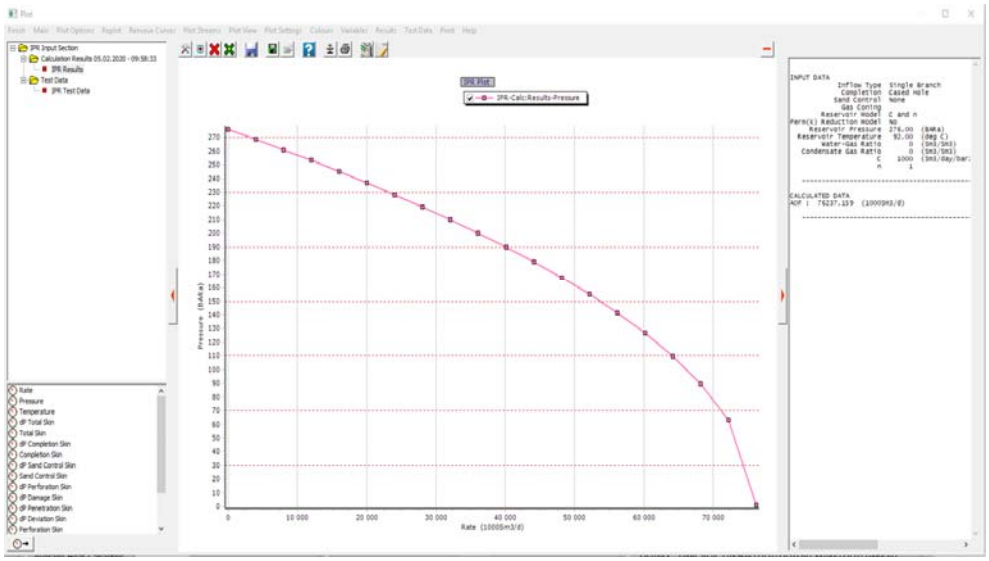
Prosper – IPR Data

-calculate & plot



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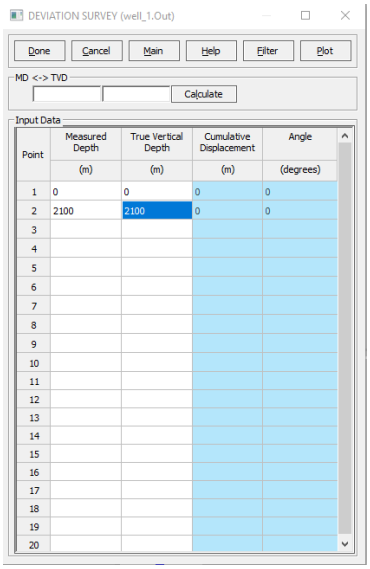
Prosper – Equipment Data



-input deviation survey
-neglect surface equipment (since we only consider the flow to wellhead)

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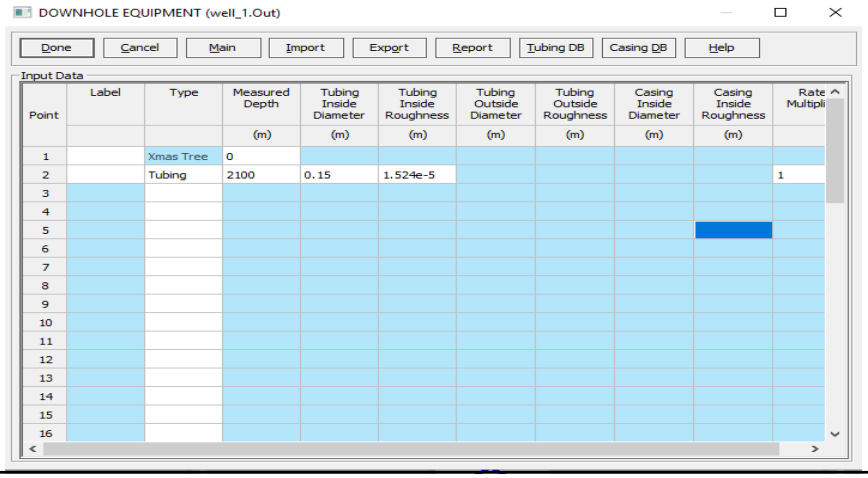
Prosper – Equipment Data

-input downhole equipment
-pay attention with the measured depth, unit of tubing ID, & roughness



Point	Label	Type	Measured Depth (m)	Tubing Inside Diameter (m)	Tubing Inside Roughness (m)	Tubing Outside Diameter (m)	Tubing Outside Roughness (m)	Casing Inside Diameter (m)	Casing Inside Roughness (m)	Rate Multipli
1		Xmas Tree	0							
2		Tubing	2100	0.15	1.524e-5					1
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										

17

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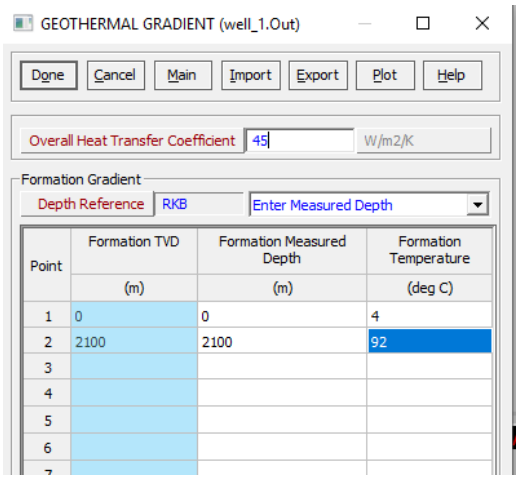
Prosper – Equipment Data

-input geothermal gradient & overall heat transfer coefficient



Point	Formation TVD (m)	Formation Measured Depth (m)	Formation Temperature (deg C)
1	0	0	4
2	2100	2100	92
3			
4			
5			
6			

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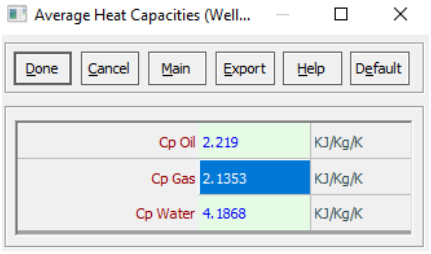
Prosper – Equipment Data

-input average heat capacities
-neglect gauge details



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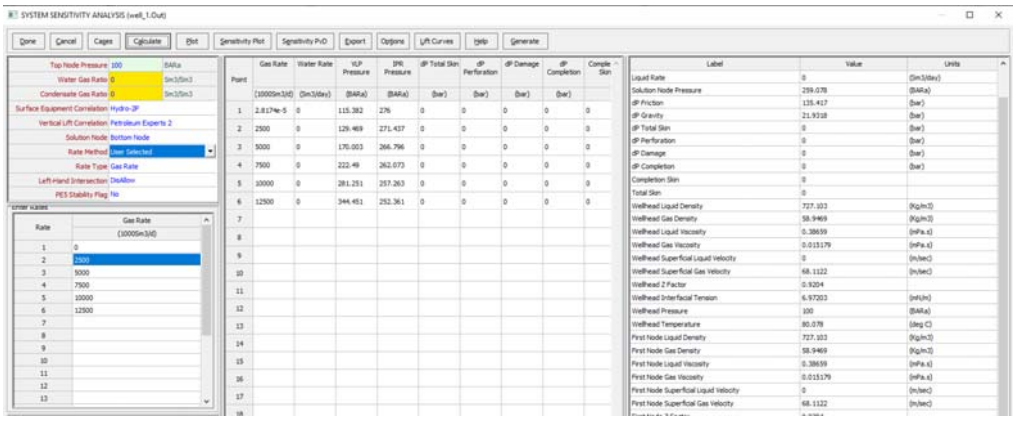
Prosper – Analysis Summary

- Estimate the producing rate using flow equilibrium assuming that the well is producing against a constant wellhead pressure of 100 bar.

-select “system” option
-input Pwh,
-use default tubing equation
-”Rate method”---User selected



20

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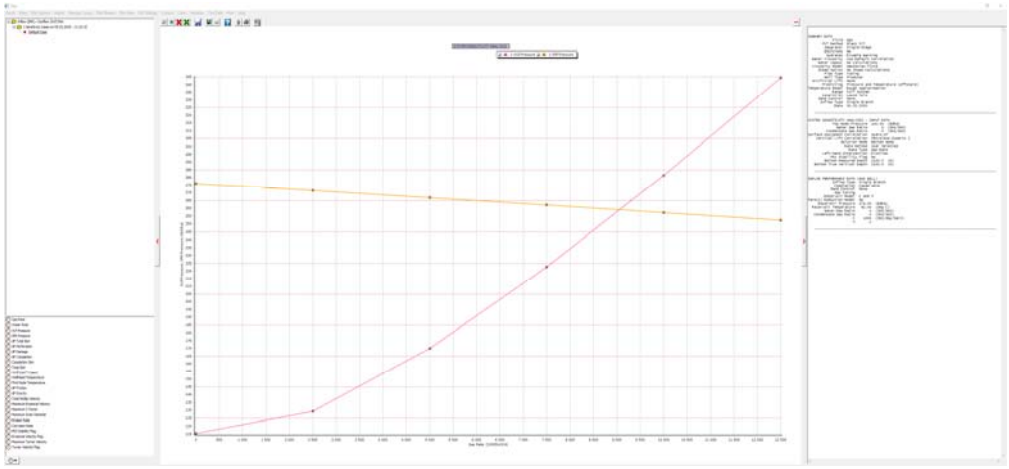
Prosper – Analysis Summary

- Estimate the producing rate using flow equilibrium assuming that the well is producing against a constant wellhead pressure of 100 bar.

-calculate
-plot → system plot → plot all cases → X-axis: liquid rate, Y-axis: VLP & IPR pressure



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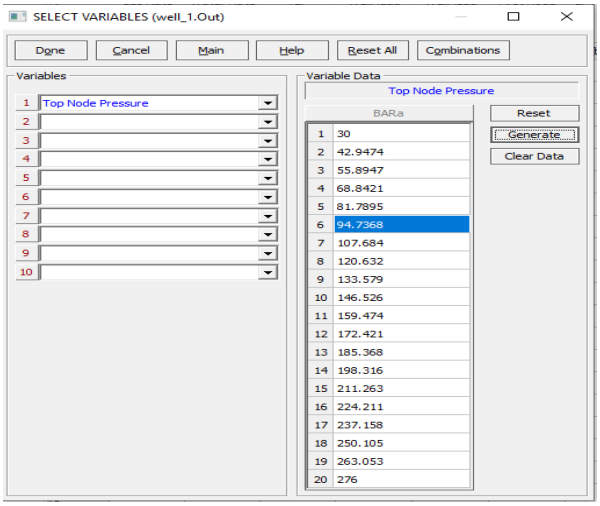
Prosper – Analysis Summary

- Generate and export lift curves to be used in GAP (in the following exercise). p_{wh} range: 30-276 bara



-generate VLP table
-select "VLP" option
-go to "cases"
-select variables & generate variable data (you can use linear spacing & 20 breakpoints). Then you have 20 cases

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Prosper – Analysis Summary

-input Pwh = 100 bara (just to avoid it complaining)
-calculate
-select “export lift curve” → choose “Petroleum Experts – GAP/MBAL” → save in the same directory as your prosper file, and with the same name
-done

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Outline

- Licensing
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- GAP: Set up Production Network
- GAP: Solve Production Network

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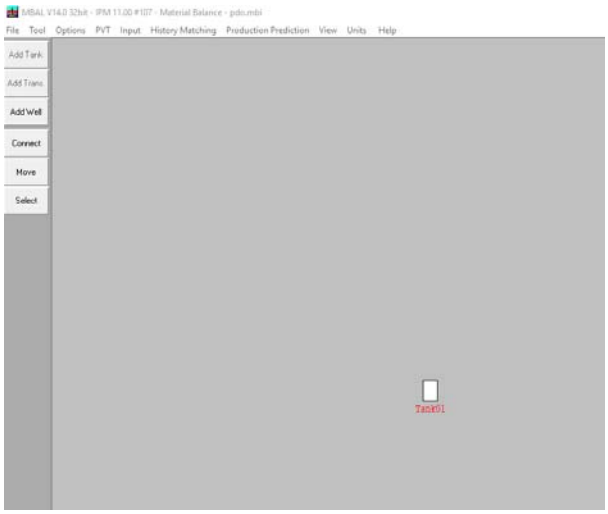
MBAL (Reservoir Model)



-open MBAL
-save as
-select “tool” → “material balance”

25

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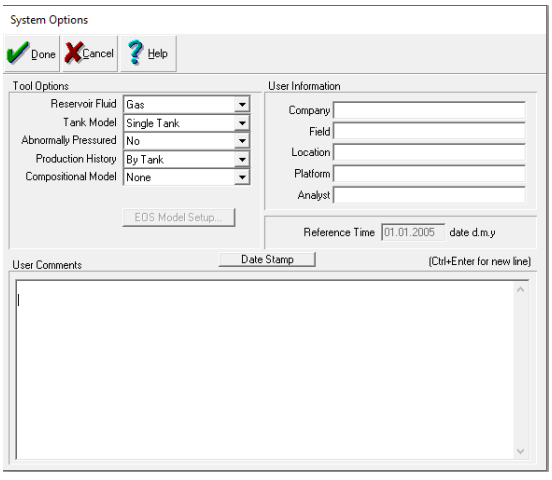
MBAL - Options



-select “options”
-use default setting

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MBAL – Unit System

-select “Units”
-change unit system to Norwegian S.I.

Unit System

Unit System

Unit Name	Unit Selections				Validation (Input Units)		
	Input	Sh/Mu	Output	Sh/Mu	Minimum	Maximum	Details
	Norwegian S.I.		Norwegian S.I.				
Compressibility	1/bar	Sh/Mu	1/bar	Sh/Mu	0	0.014503774	Details
Critical Pressure	BARa	Sh/Mu	BARa	Sh/Mu	0.94430591872	2069.440353489	Details
Critical Temperature	deg C	Sh/Mu	deg C	Sh/Mu	-272.7777505	1648.888724	Details
Critical Volume	m3/kg.mole	Sh/Mu	m3/kg.mole	Sh/Mu	0	624.3	Details

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MBAL - PVT

-select “PVT” → fluid properties
-input PVT data
-select PVT correlations

Gas - Black Oil: Data Input

Done | Cancel | Help | Match | Table | Import | Export | Calc | Match Param.

Input Parameters

Gas gravity	0.55	sp. gravity
Separator pressure	30	BARa
Condensate to gas ratio	0	Sm3/Sm3
Condensate gravity	751	Kg/m3
Water salinity	0	ppm
Mole percent H2S	0	percent
Mole percent CO2	0	percent
Mole percent N2	0	percent

Correlations

Gas viscosity: Lee et al

Use Tables
Use Matching
Model Water Vapour

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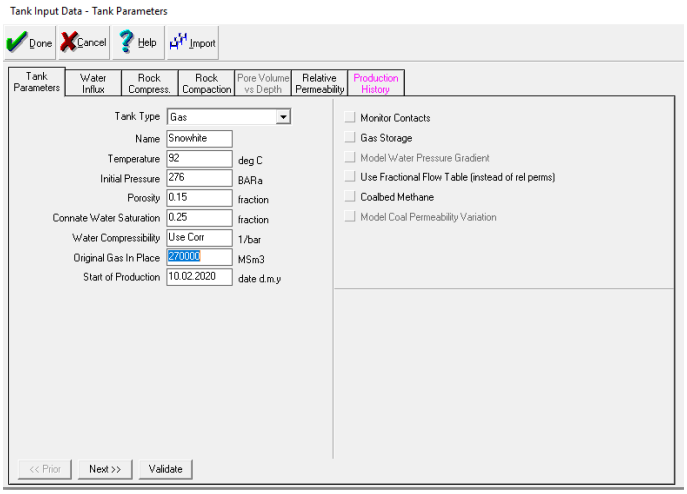
MBAL - Input



-select “Input” → tank data
-input tank parameters
-be careful with the unit of OOIP

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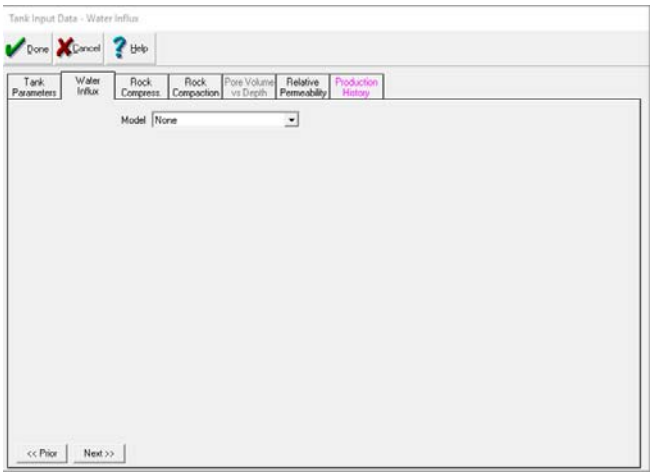
MBAL - Input



-input water influx

30

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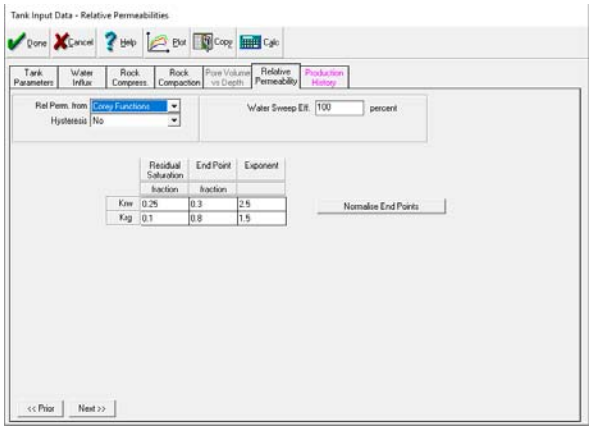
MBAL - Input



-input relative permeability

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Outline

- Licensing
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- MBAL
- GAP: Set up Production Network
- GAP: Solve Production Network

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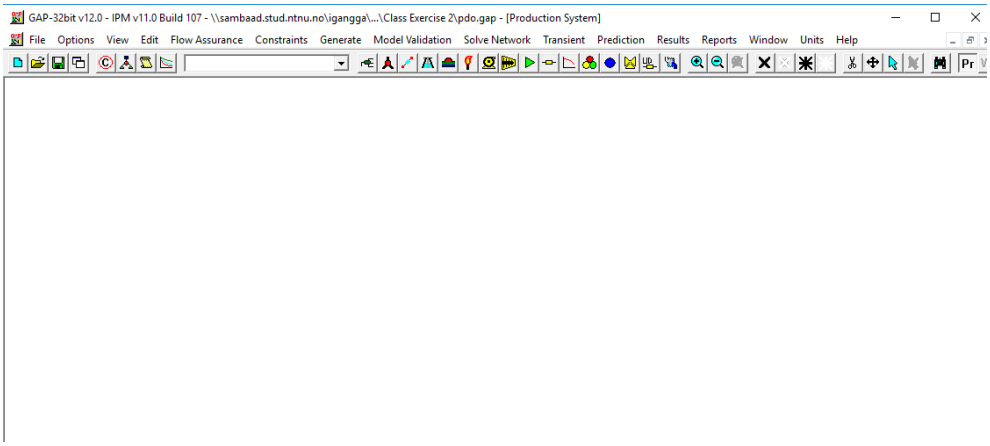
GAP (Network Model)

-open GAP
-save as



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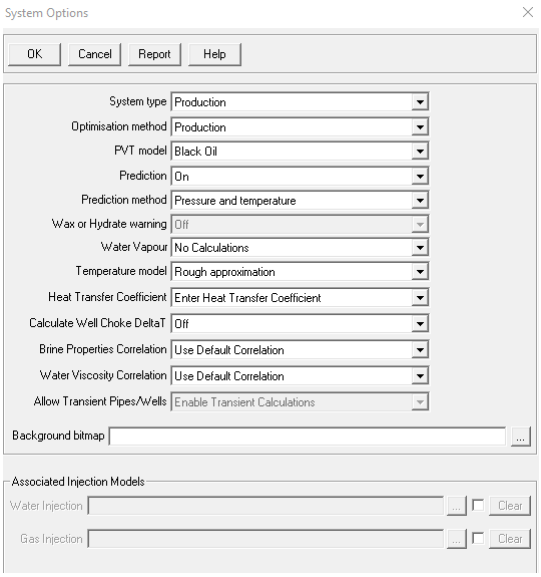
GAP



-open “options” → “method”
-system type: production
-PVT model: black oil
-for the rest, use default setting
-change unit system to Norwegian S.I.

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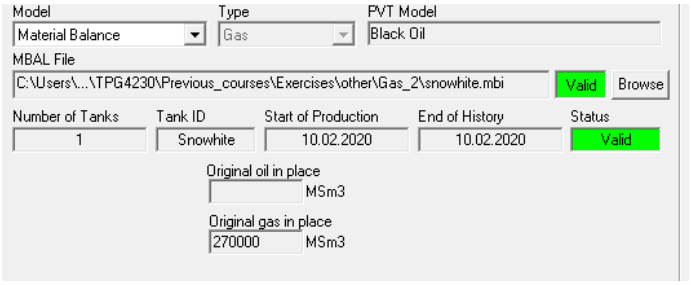
GAP: Reservoir: Summary tab

-add tank icon → rename the tank
-double click to edit tank properties
-include MBAL model
-done



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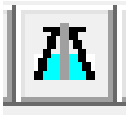
GAP: Well: Summary tab



-add well icon → rename the well
-double click to edit well properties
-'summary' tab → change welltype and add path to prosper file

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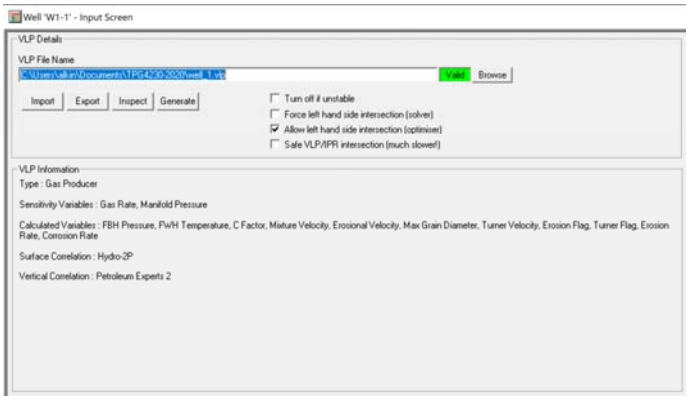
GAP: Well: Input tab: VLP Tab



-'input' tab → 'VLP' tab → 'import' VLP table in **TPD format** -done

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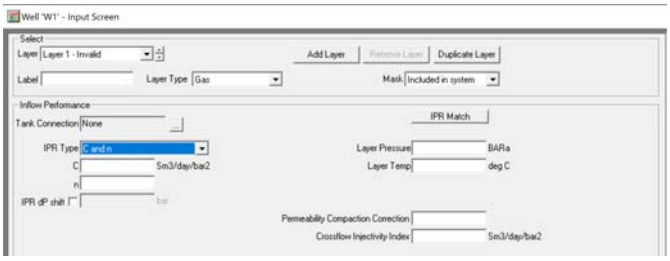
GAP: Well: Input tab: IPR Tab



- 'input' tab → '"IPR" tab
- Choose IPR type to "C and n" to have the same correlation in PROSPER

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GAP: Well

Transfer IPR data

Menu: generate – well IPR from Prosper –All - Generate

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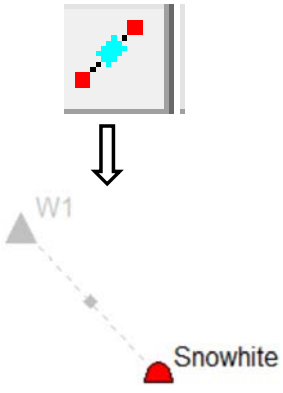
GAP: Well

-add connection between reservoir and well



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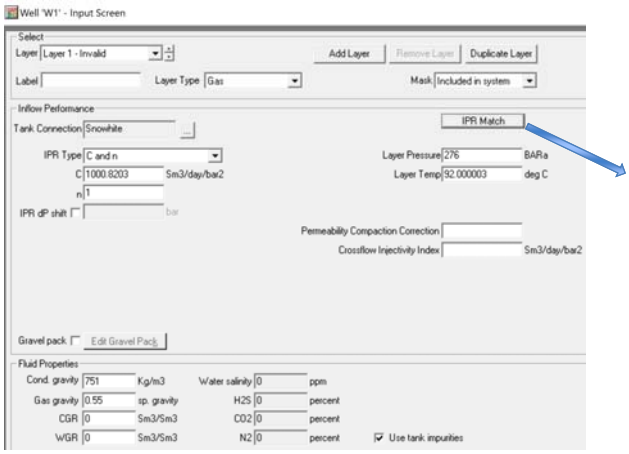
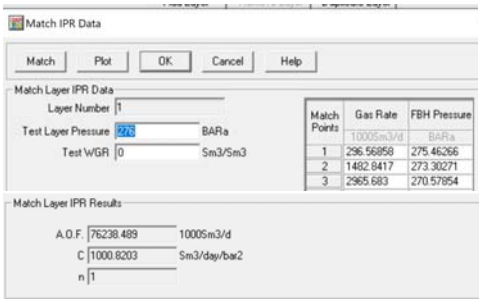
40

GAP: Well: Input tab: IPR Tab



Checking the IPR quality:
- 'input' tab → "IPR" tab -> IPR Match



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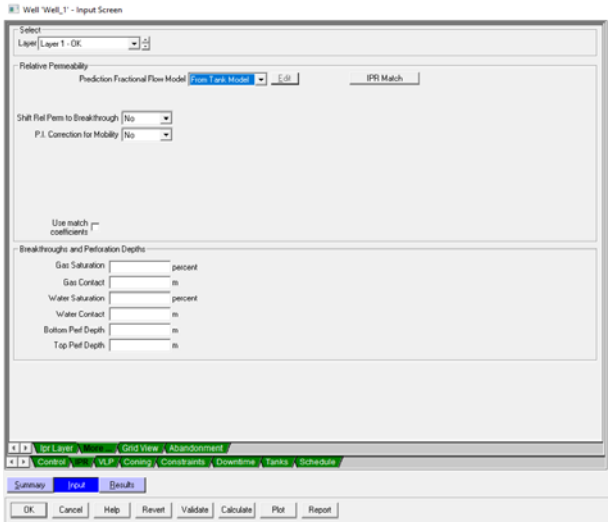
GAP: Well: Input tab: IPR Tab



-'input' tab → 'IPR' tab → 'More' sub-tab
-use permeability curve as for MBAL model ('From Tank Model')

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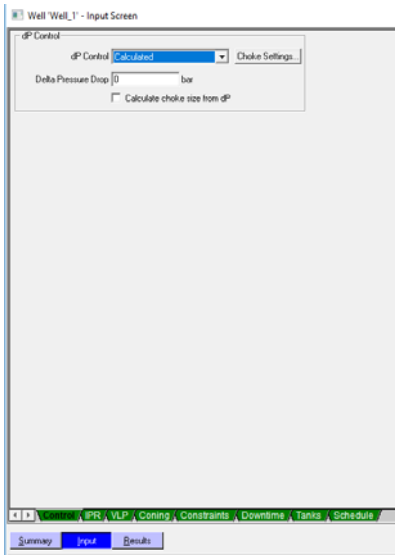
GAP: Well: Input tab: Control Tab



-'input' tab → 'control' tab
-change dp Control to allow well choking
-done

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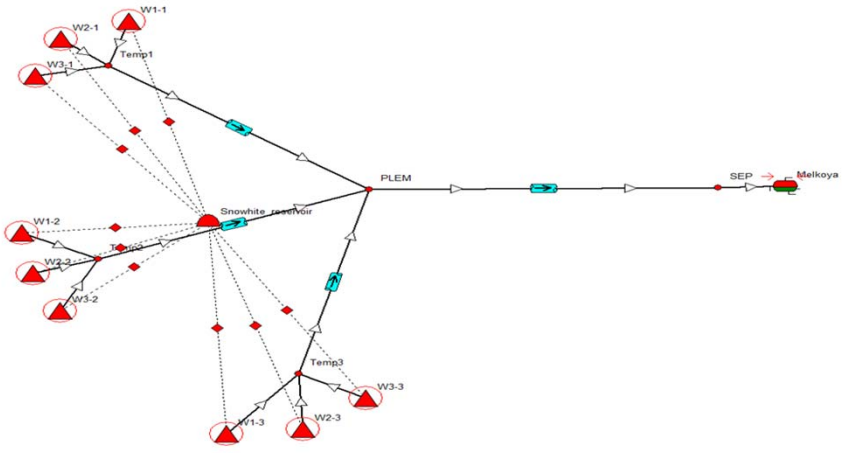
GAP: Production Layout



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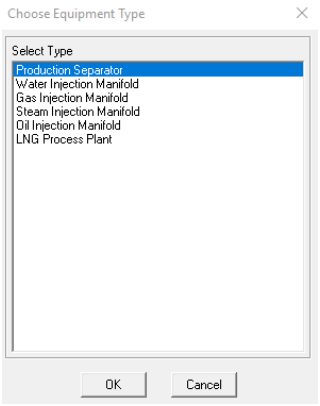
GAP: Separator

-add separator icon → choose 'production separator' → rename it
-connect the system with the separator



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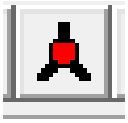
GAP: Joint (Xtree, Manifold, etc)



-add joint icon
-Rename the joint label
-pipeline is modelled between 2 joints

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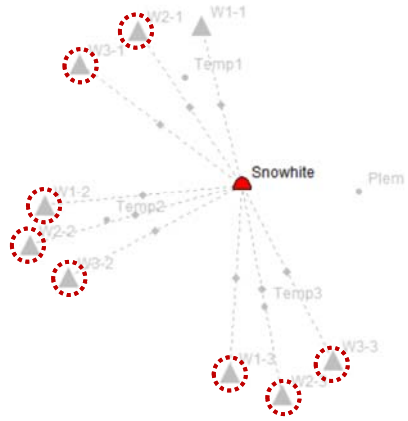
GAP: Adding more wells

-All wells are identical, thus, copy and paste wells (8 times)



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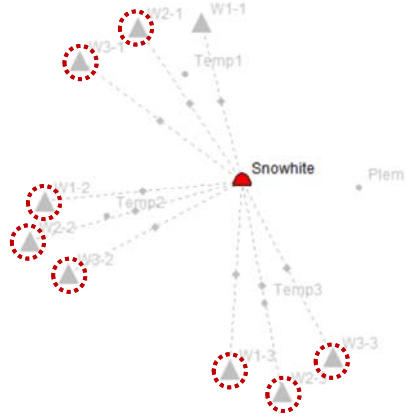
GAP: Adding more wells

-All wells are identical, thus, copy and paste wells (8 times)



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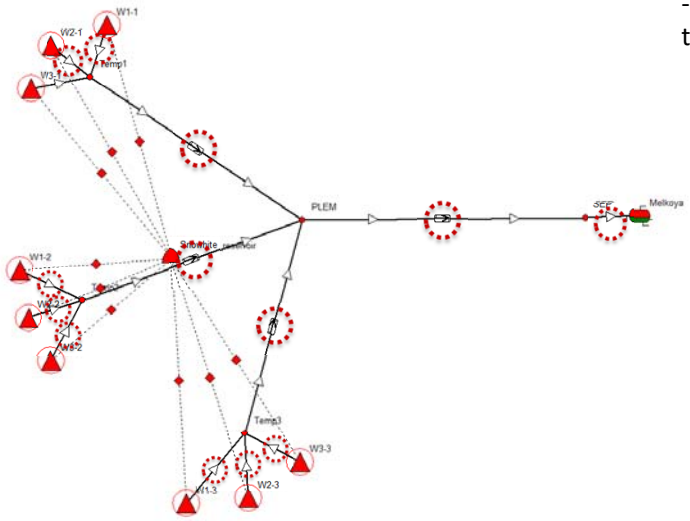
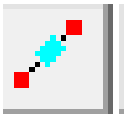
GAP: Joint (Xtree, Manifold, etc)



-connect the joints
-connect wells and separator to the joints



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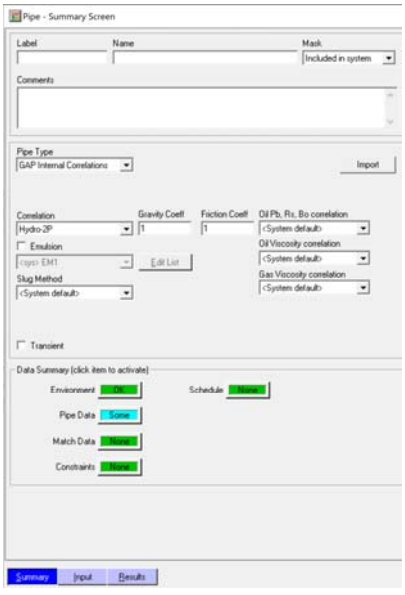
GAP: Pipeline: Summary tab



-double click in the selected pipeline
-open 'summary' tab → select PVT correlations
-leave the other things as defaults

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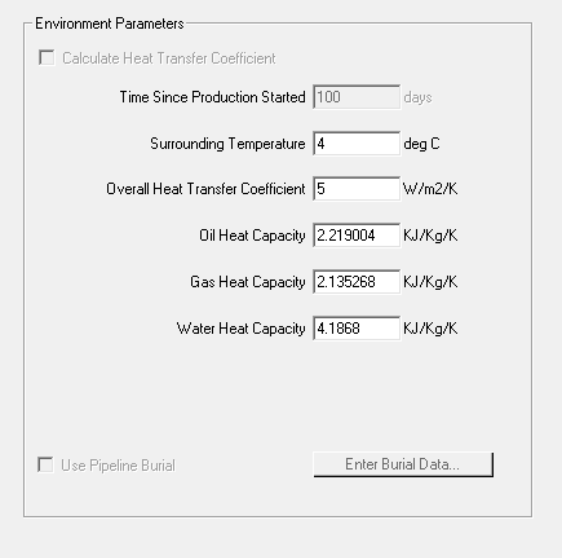
GAP: Pipeline: Input tab



-open 'input' tab → open 'environtment' sub-tab
-input ambient temperature (= 4 degC)
-input U (= 5 W/m2/K)

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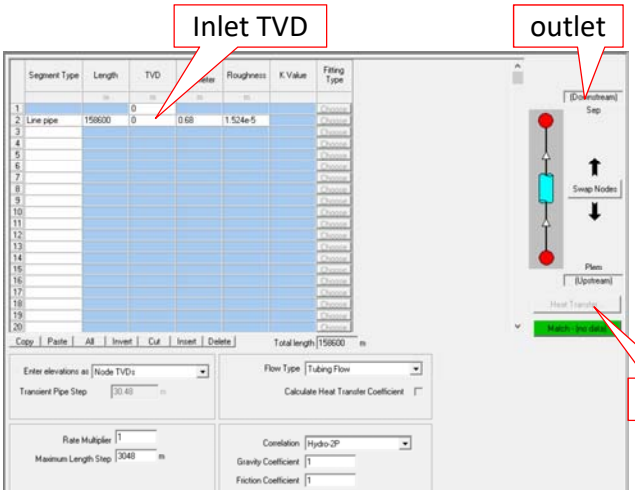
GAP: Pipeline: Input tab



-open 'input' tab → open 'description' sub-tab
-input pipeline properties: length:
5000 m for flowline
158600 m for pipeline
ID:
0.355 for flowline
0.68 m for pipeline
, roughness (=0.015 mm)
-done
-repeat for the other pipelines

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GAP: Separator

Setting up constraint

Separator 'Melkoya' - Input Screen

Constraint	Value	Binding	Potential	Unit
Maximum water rate		Yes	No	Sm3/day
Maximum gas rate	20000	Yes	No	1000Sm3/d
Maximum liquid rate		Yes	No	Sm3/day
Maximum oil rate		Yes	No	Sm3/day
Minimum gas injection rate		No	No	1000Sm3/d
Maximum CO2		Yes	No	percent
Maximum H2S		Yes	No	percent
Maximum N2		Yes	No	percent
Maximum oil specific gravity		Yes	No	Kg/m3
Maximum gross heating value		Yes	No	MW
Maximum specific gross heating value		Yes	No	kJ/sm3
Maximum Temperature		Yes	No	deg C
Unscheduled production deferment				percent

-double click on the separator icon
-open 'input' tab → open 'constraints' tab
-input the gas plateau rate

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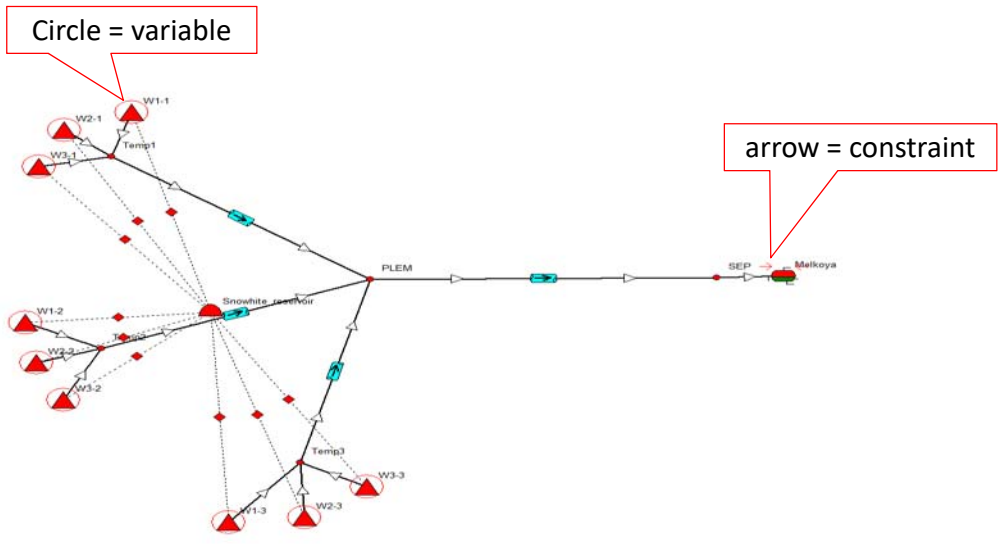
GAP: All System



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Outline

- Licensing
- PROSPER
- MBAL
- GAP: Set up Production Network
- GAP: Solve Production Network

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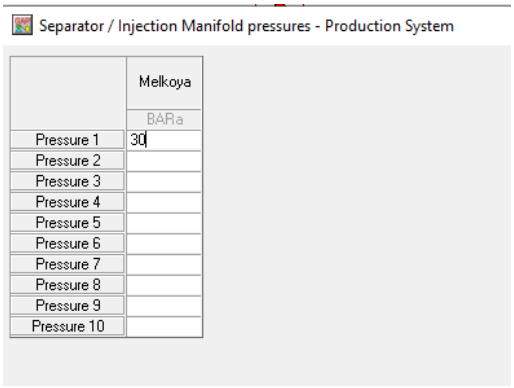
GAP: Solve Network

-open 'solve network' to solve the production network at t = 0
-run network solver
-input separator pressure



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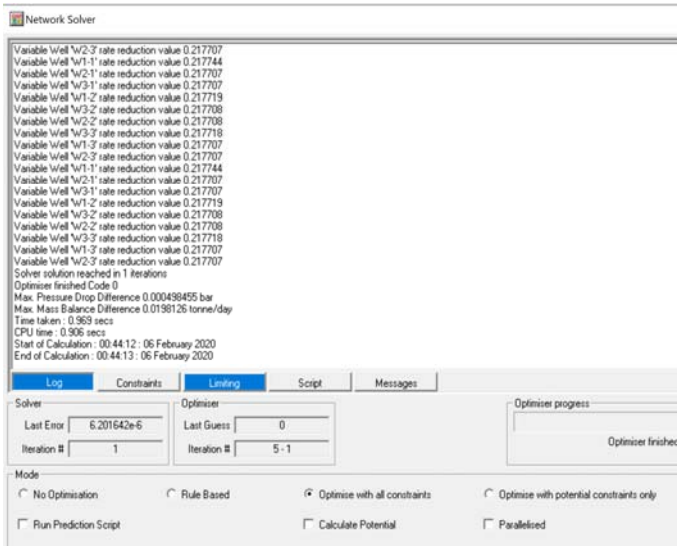
GAP: Solve Network



-since we have a constraint to be satisfy, choose 'optimise with all constraints' mode
-calculate

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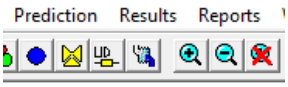
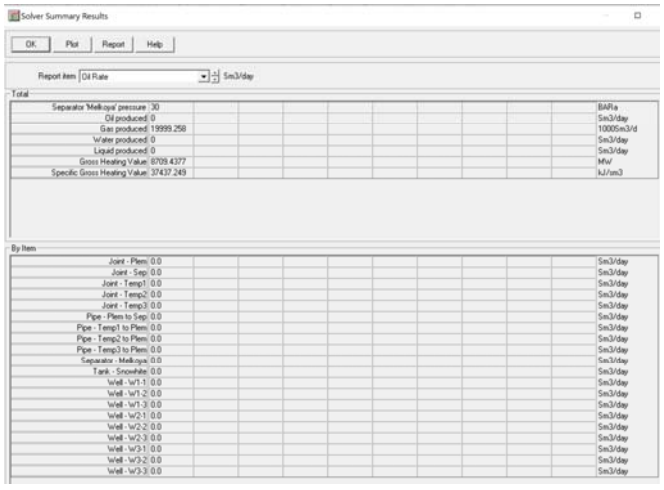
GAP: Solve Network



-to see the results, open 'results' tab → 'summary' → 'all items'



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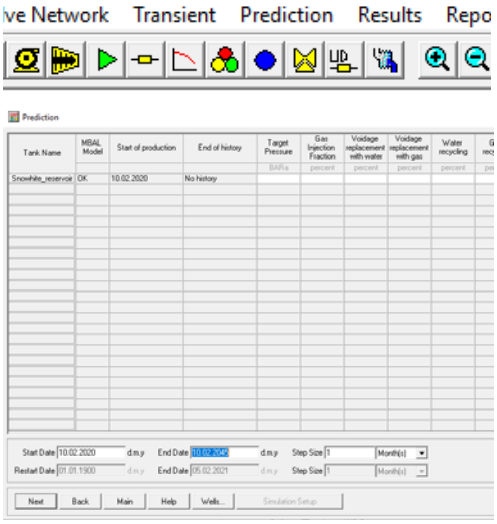
GAP: Prediction



-to generate the production profile, go to 'prediction' → 'Run prediction'
-set prediction timespan & timestep size (in this exercise, you can use dt = 1 year)

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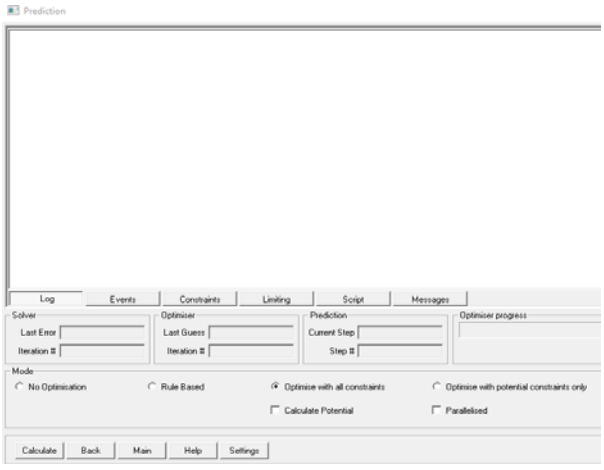
GAP: Prediction



-input separator pressure
-since we have a constraint to be satisfy, choose 'optimise with all constraints' mode
-calculate

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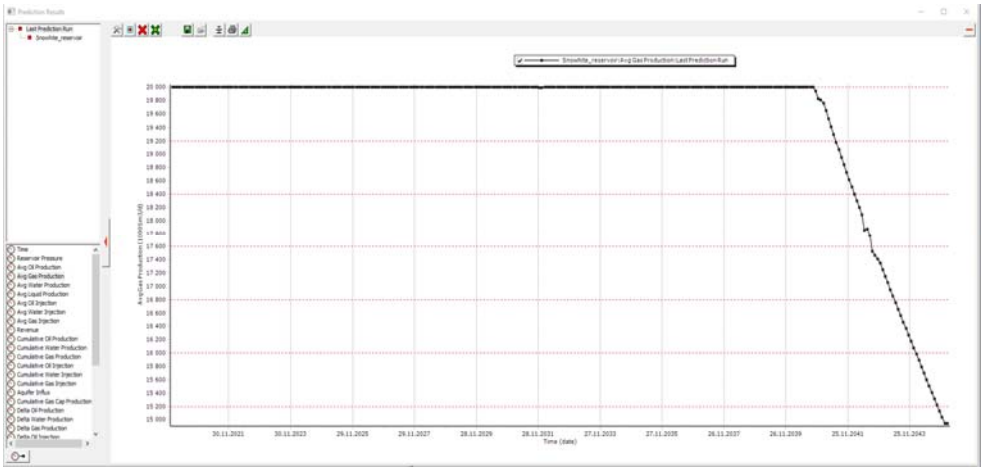
GAP: Prediction

-to see the results, open 'prediction' → 'plot nodes prediction results' → select all equipment types → plot



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Questions

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