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Modeling and Optimization of the Rich Gas-Condensate Reservoir

Upstream, Midstream and Downstream Integration

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Abstract

A composition stream from reservoir to the market has been obtained as a result of upstream, midstream and downstream retrograde gas-condensate models integration. Applications are composition, Peng-Robinson EOS has been chosen as a fluid package.

Different production scenarios were observed to define development strategy for rich gas condensate production. VGD and C/V gas drive mechanisms have been applied by dry gas cycling to enhance condensate production. Condensate production is constrained by TFGR. There are 6 producers and 4 injectors presently active in the field. Production is centered on the main process LNG plant.

IAM has been designed for accurate gas-condensate assets prediction, long term forecasting, filed development planning and modeling - optimization studies. IAM provides flexibility in global problem solving.

This master thesis will evaluate the optimal development strategy for the gas-condensate production problem. IAM provides the long term composition production forecast for gas, condensate, NGL and LNG products.

Acknowledgments

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Abbreviations

BHP………………………………………………………………………….. Bottom Hole Pressure

C/V…………………………………………………………………………..Condensing/Vaporizing

DPC …………………………………………………………………………Dewpoint Control

EOS …………………………………………………………………………...Equation of Sate

FGPR …………………………………………………………………..Field Gas Production Rate

GWC …………………………………………………………………………..Gas-Water Contact

GOR ……………………………………………………………………………Gas-Oil Ratio

IAM ………………………………………………………………………Integrated Assets Model

ID…………………………………………………………………………….. Internal Diameter

IPR ……………………………………………………………………………Inflow Performance

LNG …………………………………………………………………...Liquefied Natural Gas

NGL…………………………………………………………………... Natural Gas Liquefied

NPV……………………………………………………………………… Nett Present Value

MME …………………………………………………………...Minimum Miscibility Enrichment

MMP ……………………………………………………………Minimum Miscibility Pressure

PR ……………………………………………………………………………….Peng-Robinson

PVT …………………………………………………………..Pressure, Volume and Temperature

RF …………………………………………………………………………...Recovery Factor

VBA...…………………………………………………………………Visual Basic Application

VBS……………………………………………………………………… Visual Basic Script

VGD…………………………………………………………………... Vaporizing Gas Drive

Introduction

This master thesis provides wide description of the integrated applications, modeling and optimization of the gas-condensate field development.

Simulation and optimization of the gas-condensate production assets are important and fundamental aspects of the petroleum engineers duties requires fast problem shooting and decision making in Upstream, Midstream and Downstream applications. Obviously, modeling consists of the many independent, standalone models such as reservoir, well, pipeline, separator etc. The challenge is to obtain the whole integrated chain of the gas-condensate production.

The complexity of the “production” decision making process occurs in several cycles and requires the time is needed a whole field production observation. Integrated Assets Model is reasonable and an important aspect in order to predict an accurate field assets production, to determine the project NPV.

There are many SPE publications covered the topic were researched and studied. Douglas E. et al (1987) “SPE-12278”presented an artificial, composition modeling of gas cycling in a rich retrograde gas condensate reservoir. Zick A. (1986) “SPE-15493” presented the experimental observation of the combined condensing/vaporizing gas drive mechanism. Høier L and Whitson C.(2001) presented the MMP and MME conditions in compositionally garding reservoirs. Eikeland M. and Hansen H. (2009) discussed the production aspects of dry gas reinjection in a strong water drive “Sleipner Ost Ty” gas-condensate reservoir.

Solomon F. et al,(2008) is discussed the liquid loading phenomena occurs in gas well. Arne Fredheim, Even Solbaa (2012) – presented Natural Gas Technology.

Juell.A et al,(2009) presented an Integration and Optimization Model – Gas Cycling Benchmark contains two gas condensate reservoirs producing from a common process facility. Rahmawati S. et all.,(2010) is presented the Multi-Field Integrated Optimization Benchmark. The paper is an extension of “SPE-121252”. Two gas condensate and one oil field were observed. The I-OPT model conteins the upstream, midstream (THP-table), downstream and NPV evaluation applications integrated using PIPE-IT platform. Gonzalez.F et all,(2010) presented a Composition Integrated Asset Model for the grading, giant, near critical gas condensate field. The integrated model has upstream (Eclipse300), midstream (PIPESIM) and downstream (HYSYS) applications. The integration was done using the mass rate composition stream.

Problem Formulation

Object of this master thesis is a development of the rich gas-condensate field in 15 years with high efficiency. Efficiency of the field production strongly depended on the interaction of the upstream, midstream and downstream development strategies.

Traditionally, the field development strategy required a wide engineering to model the upstream, midstream and downstream applications. Obviously, those applications are modeled and optimized independently.

Integrated Assets Model (IAM) has been developed in order to define development strategy of the rich gas-condensate field. The model consists of the upstream (SENSOR), midstream (PIPESIM) and downstream (HYSYS) integrated in a PIPE-IT platform.

Motivation

Today, the word energy demand is extremely high. Currently, it is covered by conventional oil and gas reservoir. The future word energy demand will be increased, at the same time the percentage of the conventional resources will declined. The only one way to cover the “energy gap” is to produce technology for the unconventional (shale gas, shale oil, tight gas, HTHP reservoirs, deepwater reservoir etc) resources production.

The literature listed above pointed on the improving assets production from the rich gas-condensate, unconventional, reservoirs.

There is a good opportunity to demonstrate the fundamental understanding of the whole production chain of the rich gas condensate field development. Different types of problems were solved by integrating, modeling and optimizing the upstream, midstream and downstream applications.

Software Overview

SENSOR (System for Efficient Numerical Simulation of Oil Recovery) is a dynamic reservoir simulator, developed by Coats Engineering, Inc. The simulator is suitable for the composition and black oil fluids. (Coats Engineering)

PIPESIM is a steady-state, multiphase flow simulator used for the design and diagnostic analysis of oil and gas production system. PIPESIM 2011.1 was developed by Schlumberger - leading of the Production Engineer software company. (Schlumberger, 2011)

HYSYS is a thermodynamic, steady-state and dynamic, multiphase simulator used for design and diagnostic analysis of the oil and gas surface process system. HYSYS 7.3 was developed by Aspen Technology, Inc, considered to be one of the leading software packages of downstream process. (Aspen Technology)

Petrostreamz PIPE-IT this is software specially designed for integrated asset optimization, modeling and exploitation in the petroleum industry. PIPE-IT was developed by the Norwegian company Petrostreamz AS owned by Curtis H.Whitson. The PIPE-IT GUI enables the user to pipe his project in different layers vertically and horizontally. (Petrostreamz)

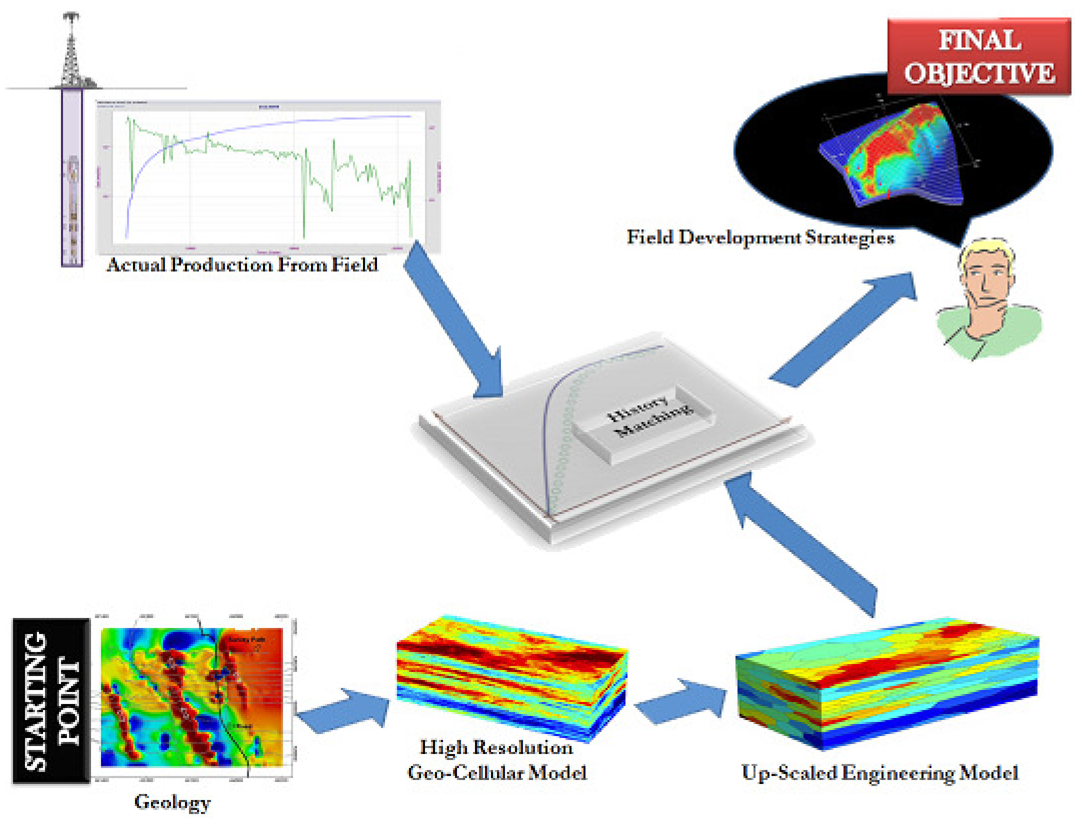
Upstream, Midstream and Downstream Models

Upstream

Introduction

Reservoir simulation is an important method in the Petroleum Industry, particularly for the field development and asset-management evaluation. Development strategy, forecasting, history matching and asset evaluation are an important application in reservoir simulation techniques.

The object of reservoir modeling is to evaluate the optimal production strategy for the gas-condensate reservoir. Define and apply the mechanisms to enhance the condensate production is primary target in field development strategy. Picture below shows upstream engineering applications.



Model

The three major parts to a composition modeling of the rich gas-condensate reservoir study are PVT data, Reservoir Grid and Gas Cycling. The PVT data was scaled up from Douglas E. Kenyon et al SPE-3 “Gas Cycling of Retrograde Condensate Reservoir”.

The reservoir model contains 27x27x4 each grid block has a dimensions dx=293.3 ft and dy=293.3 ft. The model is shown on Figure 1. The layers are homogenous with a constant porosity and permeability. The thicknesses are varying among the layers from the 30 to 50 ft. The specification of the rich gas-condensate reservoir is presented in Table 1.

The grid size represents the most reasonable grid for offshore fields and sets the value of numerical dispersion in IMPES model. (Kenyon, 1987)

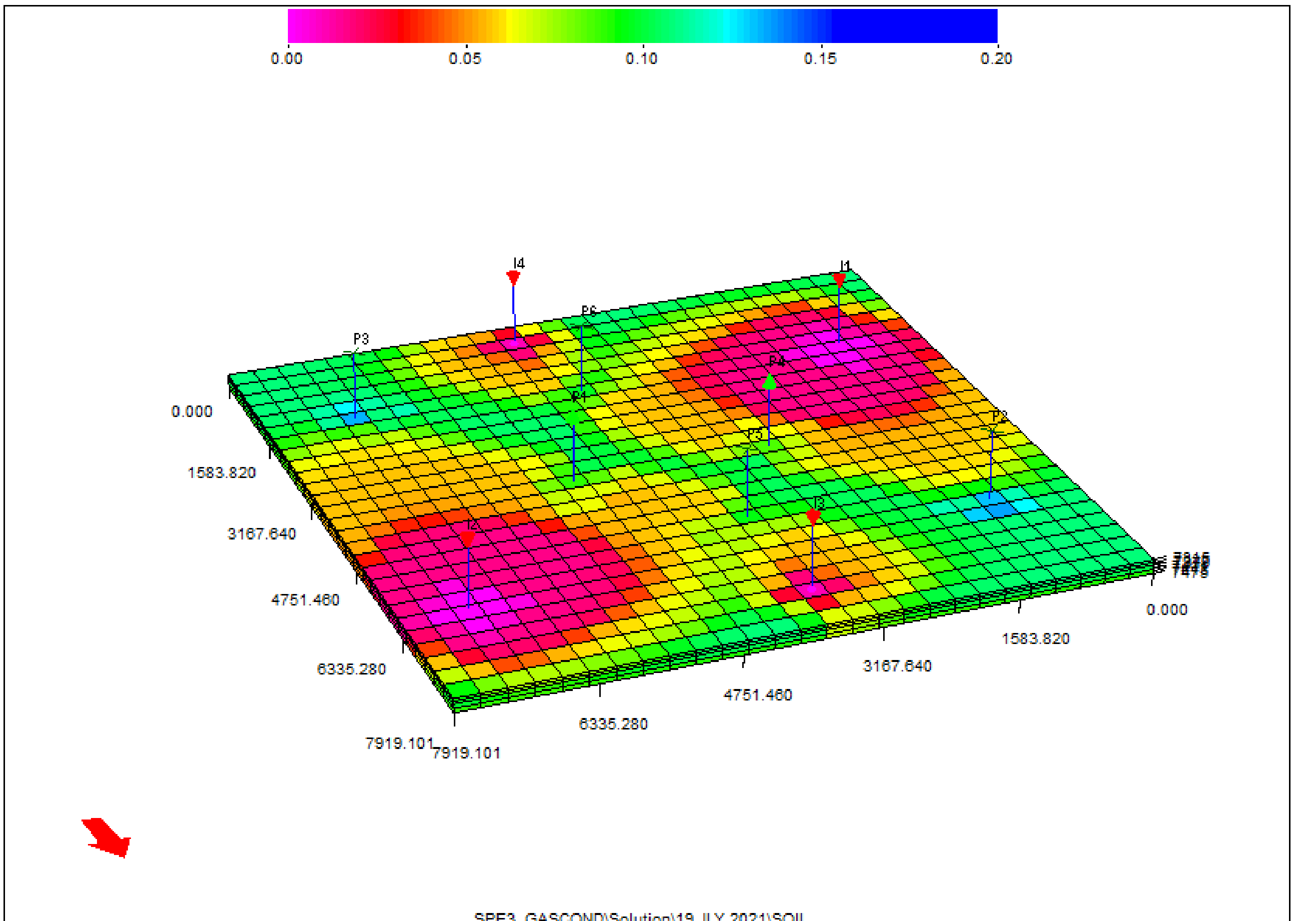


Figure 1 Reservoir Model “Rich Gas-Condensate Reservoir”

There are six identical producers and four identical injectors are in the reservoir. The locations of the producers are in the middle of the reservoir. The injectors are around in the reservoir. The wells locations and specifications are presented in Table 1.

nX=nY		27
nZ		4
dX=dY	ft	293.3
Subserface	ft	7500
Porosity		0.13
GWC		7500
Initial Pressure, psia		3550
Water Compressibility	psi^{-1}	$3*10^{-6}$

Layer	Kx. Ky mD	Kz mD	Thickness ft	Depth, ft
1	100	100	30	7330
2	100	100	30	7360
3	100	100	50	7400
4	100	100	50	7450

Sw	krw	Krow	krg	Pcwo
0.16	0	0.8	0.74	50
0.2	0.002	0.65	68	32
0.24	0.01	0.513	62	21
0.28	0.02	0.4	562	15.5
0.32	0.033	0.315	0.505	12
0.36	0.049	0.25	0.45	9.2
0.4	0.066	0.196	4 0.	7
0.44	0.09	0.15	0.348	5.3
0.48	0.119	0.112	.3 .	4.2
0.52	0.15	0.082	0.26	3.4
0.56	0.186	0.06	0.222	2.7
0.6	0.227	0.04	187	2.1
0.64	0.277	0.024	0.156	1.7
0.68	0.33	0.012	0.126	1.3
0.72	0.39	0.005	0.1	1
0.76	0.462	0	0.078	0.7
0.8	0.54	0	58	0.5
0.84	0.62	0	0.04	0.4
0.88	0.71	0	0.026	0.3
0.92	0.8	0	0.013	0.2
0.96	0.9	0	0.005	0.1
1	1	0	0	0

Well Locations — Separator Condition

WELSPECS	SEPARATOR
I1 FIELD 7 4 7330 GAS / I2 FIELD 22 25 7330 GAS / I3 FIELD 25 13 7330 GAS / I4 FIELD 2 16 7330 GAS P1 FIELD 14 18 7400 GAS / P2 FIELD 21 4 7400 GAS / P3 FIELD 6 24 7400 GAS / P4 FIELD 14 10 7400 GAS / P5 FIELD 19 13 7400 GAS / 6 FIELD 7 15 7400 GAS /	T=80F, P=805 psia T=80F, P=65 psia T=60F, P=14.7 psia

Well Completion: INJECTORS 1-2 layer, PRODUCERS 3-4 layer

Development Cases

1. Depletion
   - Gas Rate 5000Mscf/day
   - Gas Rate 15000Mscf/day
2. Gas Cycling
   - 2 INJECTORS
     Gas Injection Rate 10000Mscf
     Gas Injection Rate 20000Mscf
     Gas Injection Rate 30000Mscf
   - 4 INJECTORS
     Gas Injection Rate 30000Mscf
     Gas Injection Rate 10000Mscf
3. Combined
   - Depletion first 3Year, Gas Cycling and blowdown
     - ✓ Different Injection Gas Rate
     - ✓ Different Injection Start-up

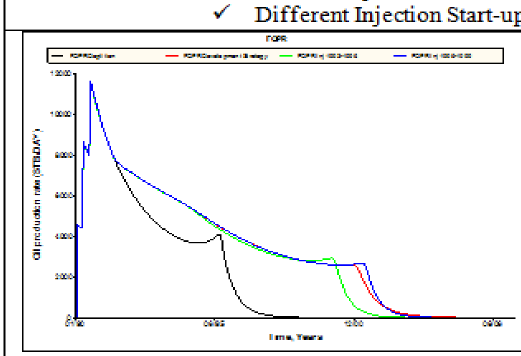


Table 1 Specification of the Gas-condensate Field

The initial conditions for the location of the GWC and the capillary pressure generate the gas zone. The aquifer plays insignificant role due to small water compressibility. Therefore the trapping of injected dry-gas is insignificant. (Kenyon, 1987)

Production is controlled by three stage separators conditions (P, T) and the produced gas rate. The area around the producers undergoes pressure depletion due to production of the gas thus, in this area, retrograde condensation occurs.

PVT Data

Composition was scaled up from SPE3 “Gas Cycling of Retrograde Condensate Reservoirs”. The composition for the gas-condensate reservoir consists of 9 components. The initial fluid composition of the gas-condensate reservoir is shown in Table 2 and Table 3.

NO.	NAME	PC	TC	MW	PCHOR	AC	SHIFT
		psia	R				
1	CO2	1070.7	547.58	44.01	0	0.225	-0.00089
2	N2	491.68	227.29	28.02	0	0.04	-0.16453
3	C1	670.1	335.9	16.04	0	0.013	-0.17817
4	C2	707.79	549.59	30.07	0	0.098	-0.06456
5	C3	616.41	665.73	44.1	0	0.152	-0.06439
6	C4-6	498.2	713.2	67.28	0	0.234	-0.18129
7	C7P1	376.2	1030.5	110.9	0	0.332	0.1208
8	C7P2	245.4	1134.4	170.9	0	0.495	0.23442
9	C7P3	124.9	1552.7	282.1	0	0.833	0.54479

Table 2 “Equation of Sate (EOS) properties”

	CO2	N2	C1	C2	C3	C4-6	C7P1	C7P2	C7P3
CO2	0	-0.02	0.1	0.13	0.135	0.1277	0.1	0.1	0.1
N2	-0.02	0	0.036	0.05	0.08	0.1002	0.1	0.1	0.1
C1	0.1	0.036	0	0	0	0.09281	0	0	0.1392
C2	0.13	0.05	0	0	0	0	0.00385	0.0063	0.006
C3	0.135	0.08	0	0	0	0	0.00385	0.0063	0.006
C4-6	0.1277	0.1002	0.09281	0	0	0	0	0	0
C7P1	0.1	0.1	0	0.00385	0.00385	0	0	0	0
C7P2	0.1	0.1	0	0.0063	0.0063	0	0	0	0
C7P3	0.1	0.1	0.1392	0.006	0.006	0	0	0	0

Table 3 “Binary Iteration Parameters (BIP)”

Result

Composition model has been run using Eclipse 300 and SENSOR reservoir simulators. Different development cases were studied such as Depletion, Gas Cycling and Mixing Case in order to define the development strategy presented in Table 1.

Depletion Case:

During the depletion scenario, gas-condensate reservoir is depleted very fast. The retrograde condensate occurs in lower layers around the producers due to reservoir depletion. Condensate is immobile phase therefore production is sharply goes down. Increasing gas production rate, the field is depleted much faster due to mass balance. Results are presented on Figure 2, Figure 4 and Figure 4.

Figure 2 shows how fast reservoir is depleted using different gas production rate. Gas/Oil ratio presented on Figure 4 is continually raised in production time. Production assets presented on Figure 4 shows gas recovery factor is riched 84% during depletion case. The condensate recovery factor is riches 32%. Such insignificant condensate recovery is the consequence of the drainage strategy applied for the production.

Increasing gas production, the ultimate recovery factors for the gas and condensate are same in both cases. The difference is only production time.

Summary for the Depletion case presented on Figure 2 and Figure 4:

1. Reservoir pressure dramatically decreases
2. Production rate has an impact for production time
3. Recovery Factors are same in both cases. RF = 32% condensate and 84% for gas.
4. Significant amount of intermediate components (condensate) are not recoverable.
5. GOR is constantly raised.

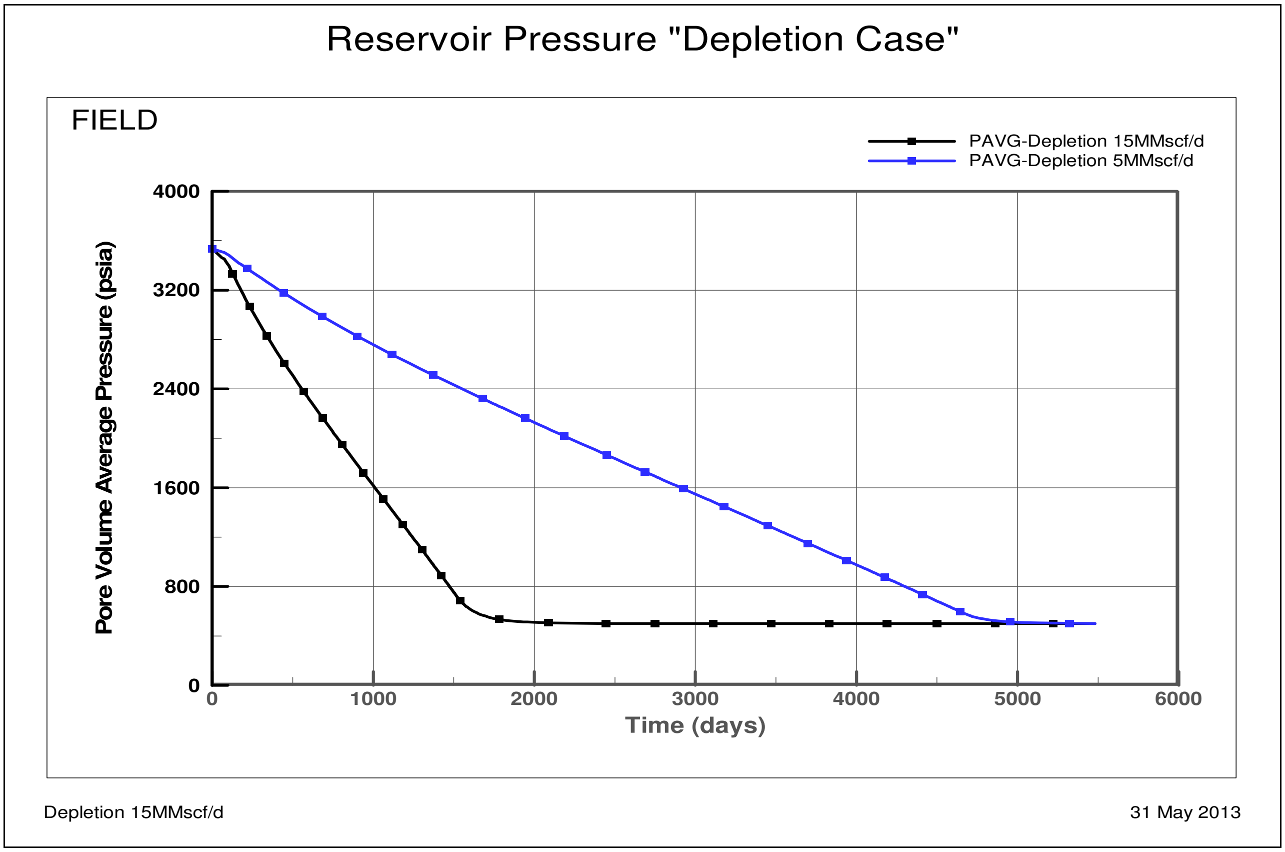


Figure 2 Pore Volume Average Pressure "Depletion" case

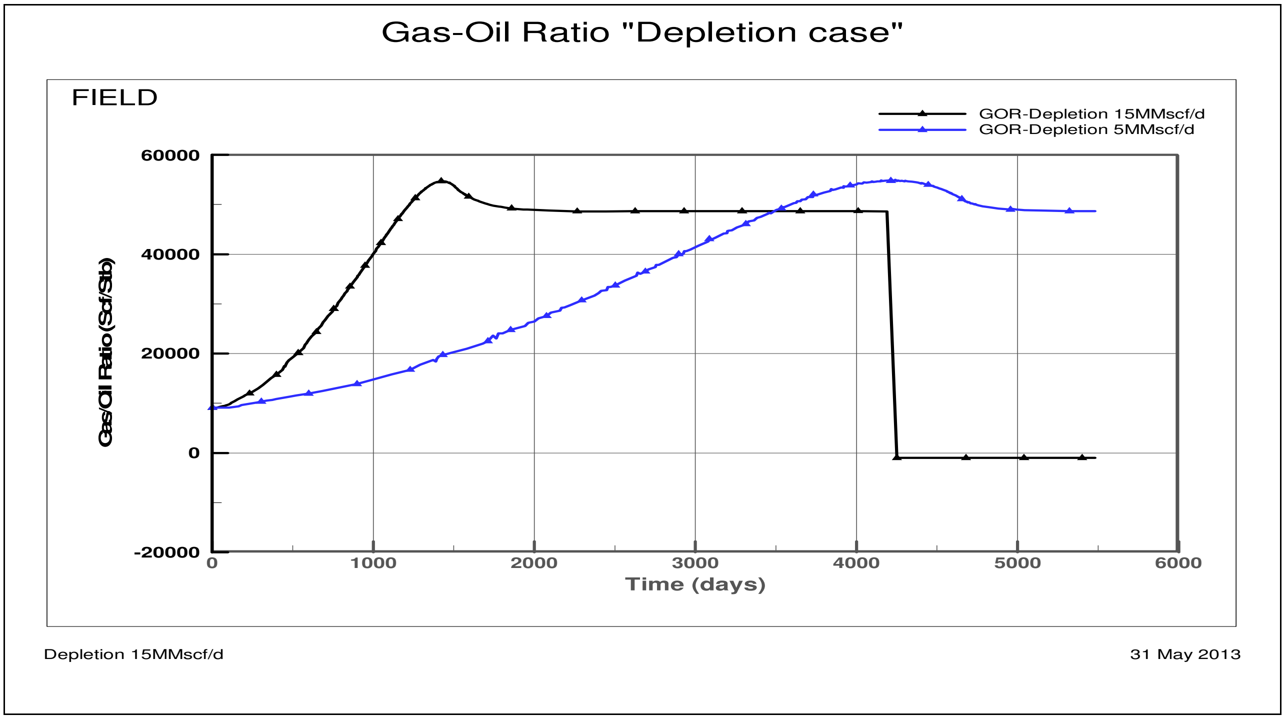
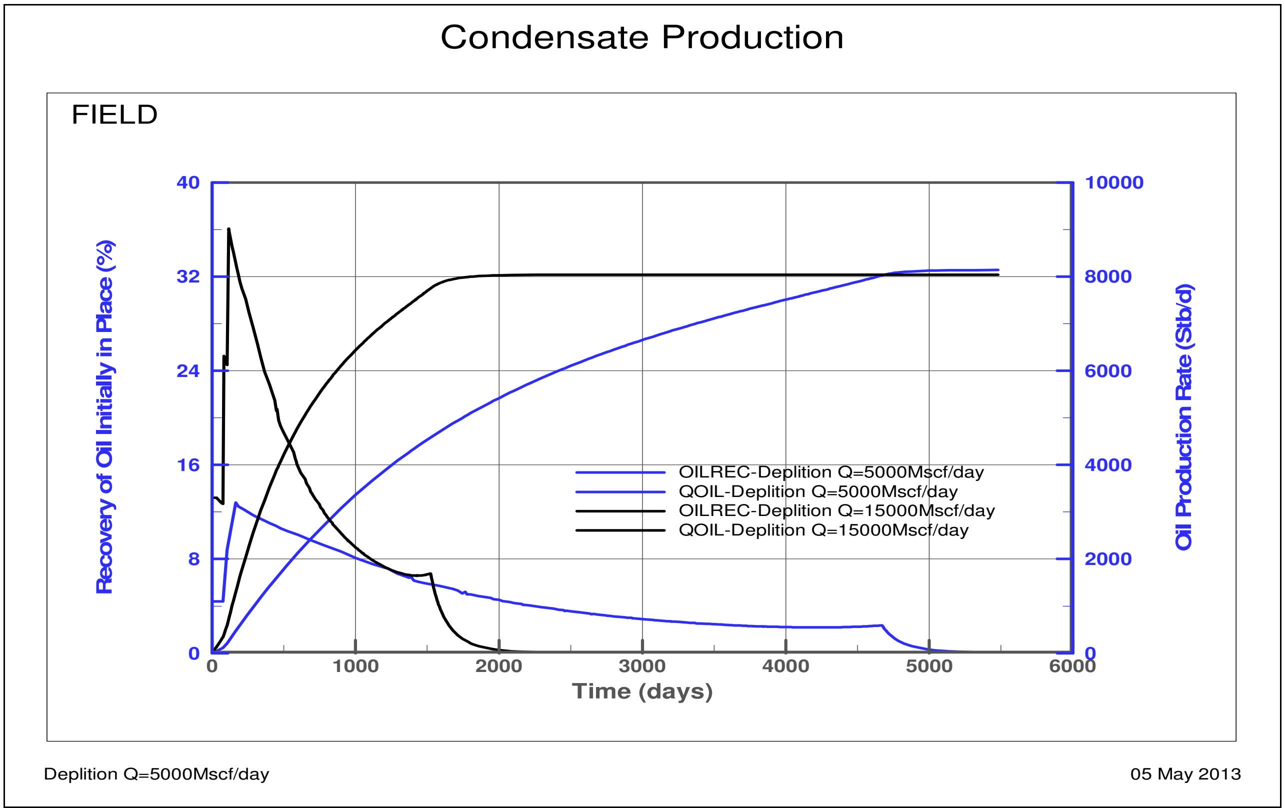


Figure 3 Gas/Oil Ration "Depletion"



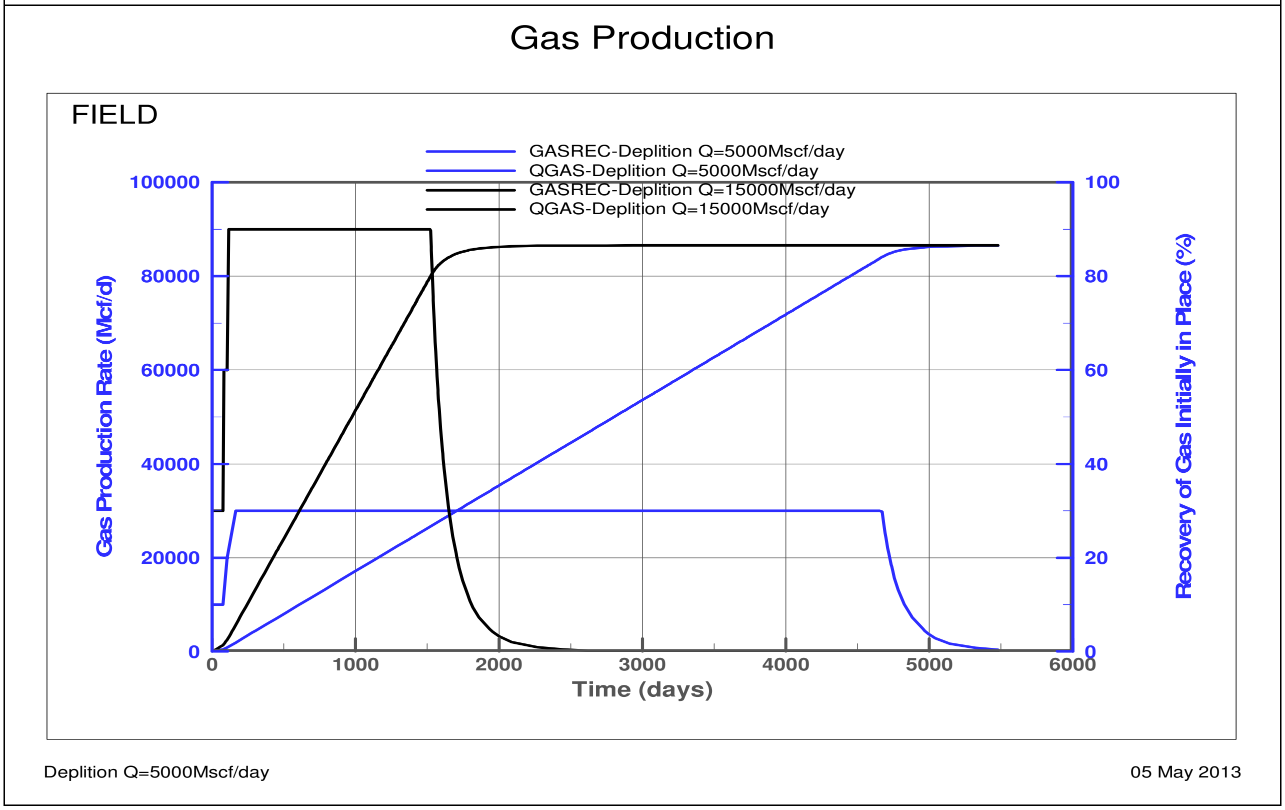


Figure 4 Recovery Factor and fluids Production "Depletion" case

Gas cycling case:

During the gas cycling case, produced gas is injected back in order to maintain the reservoir pressure and enhance the condensate production and ultimate condensate recovery. Produced and separated “lean” gas is mainly consist of light components C1-C3 is vaporized the intermediate components C3-C7++ from the retrograde immobile condensate therefore the ultimate condensate recovery increased.

The mechanisms to enhance condensate reservoir are called Vaporizing Gas Drive (VGD) and Condensing/Vaporizing Gas Drive (C/V).

Gas cycling can be first-contact and multi-contact miscible. Minimum miscibility pressure (MMP) and minimum miscibility enrichment (MME) determines the miscibility conditions for the gas –gas displacement. First contact MMP for the gas-condensate fluid is equals to the dewpoint pressure. For the multi contacts case the MMP less than dewpoint pressure. There are several methods to determine the MMP: “Slim tube test” (RF>90%)” and “Multi Contact Miscibility Test”.

There are several “gas cycling” cases were studied using two and four injection wells with various gas injection rate. Gas injection is maintained the reservoir pressure at a level would sustain the production rate. Thus, the reservoir pressure is slightly decreased in compare with depletion case. For the different injection rate, the drainage strategy has a different efficiency. The reservoir pressure decreased slightly for the high injection rate. Result is shown on Figure 5.

Oil (condensate) production is sharply decreased due to reservoir depletion in first 600 days. The oil production, presented on Figure 7, decreased slightly at the period when drainage strategy “gas cycling” has been applied to maintain reservoir pressure and enhance the ultimate condensate production. Condensate production goes up slightly before the blowdown that happens because of “retrograde phase behavior” and then significantly drops down due to depletion.

Condensate recovery factor, presented on Figure 7, for those scenarios is lying in range 42%-58%. Recovery for the “gas cyclic “drainage strategy is significantly increased in compare with “depletion” case. The condensate recovery enhanced from 10% to 26%.That is happing because of the most retrograde area is swept by injection “lean” gas and C/V mechanism is taking place.

Gas production, presented on Figure 7, riched the planned filed rate 90000 Mscf/day in short time, 105 days. The length of the plateau is significantly sensitive on the drainage strategy applied to enhance condensate production. Plateau is extending with increasing the injection rate. Gas recovery factor for the “gas cycling” and “depletion” scenarios is 84%. Thus, the drainage strategy does not enhance the gas ultimate recovery.

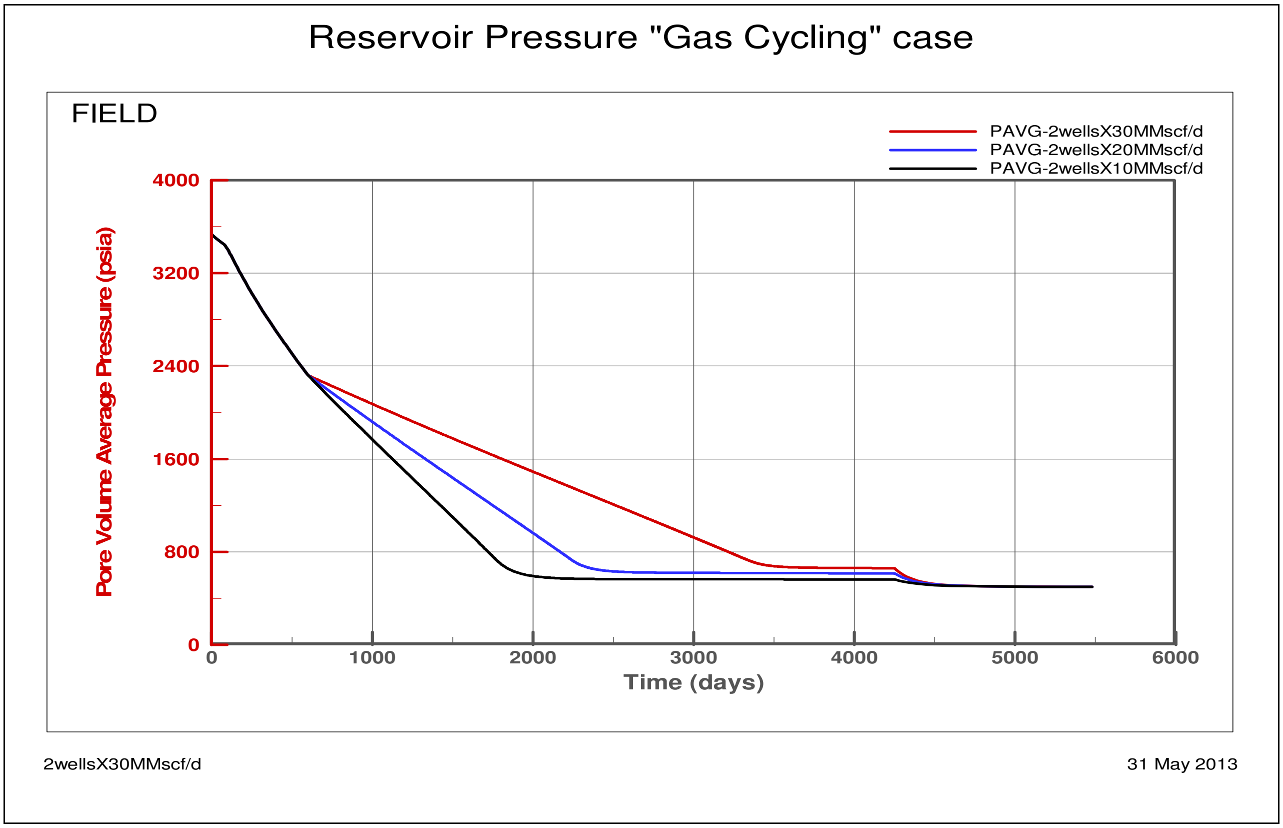


Figure 5 Reservoir Pressure “Gas Cycling” case

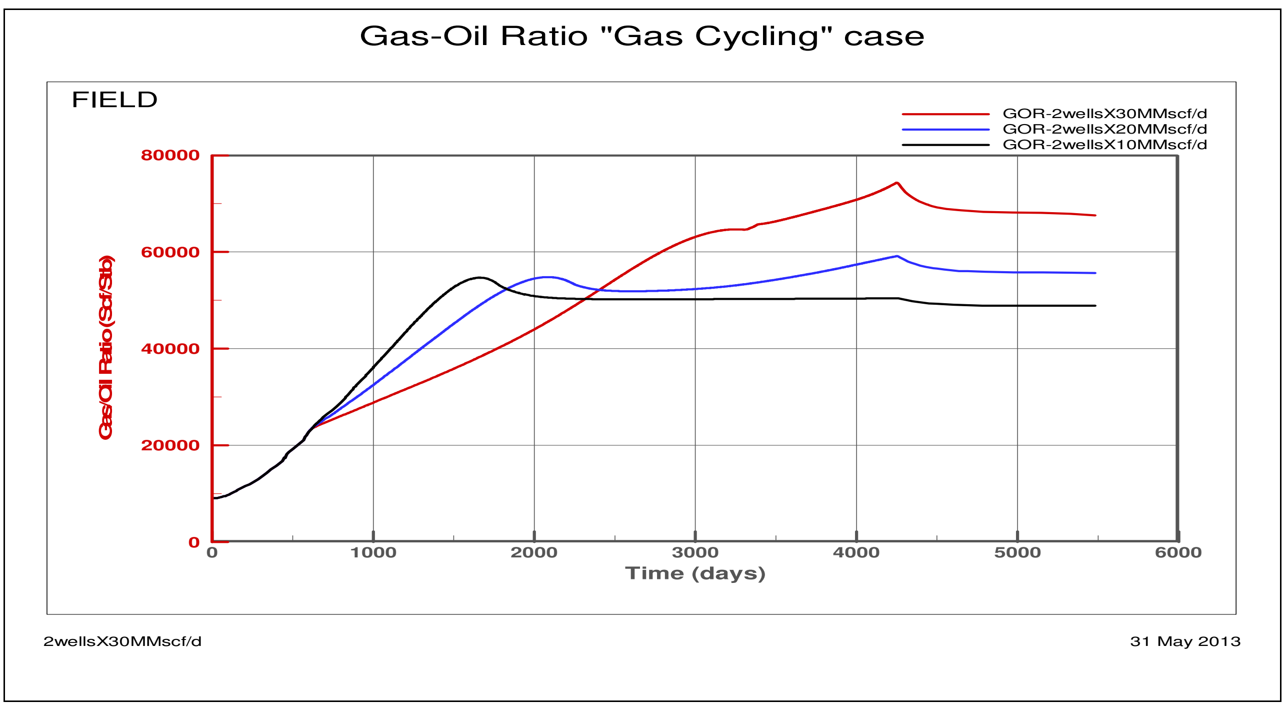


Figure 6 Gas/Oil Ratio "Gas Cycling"

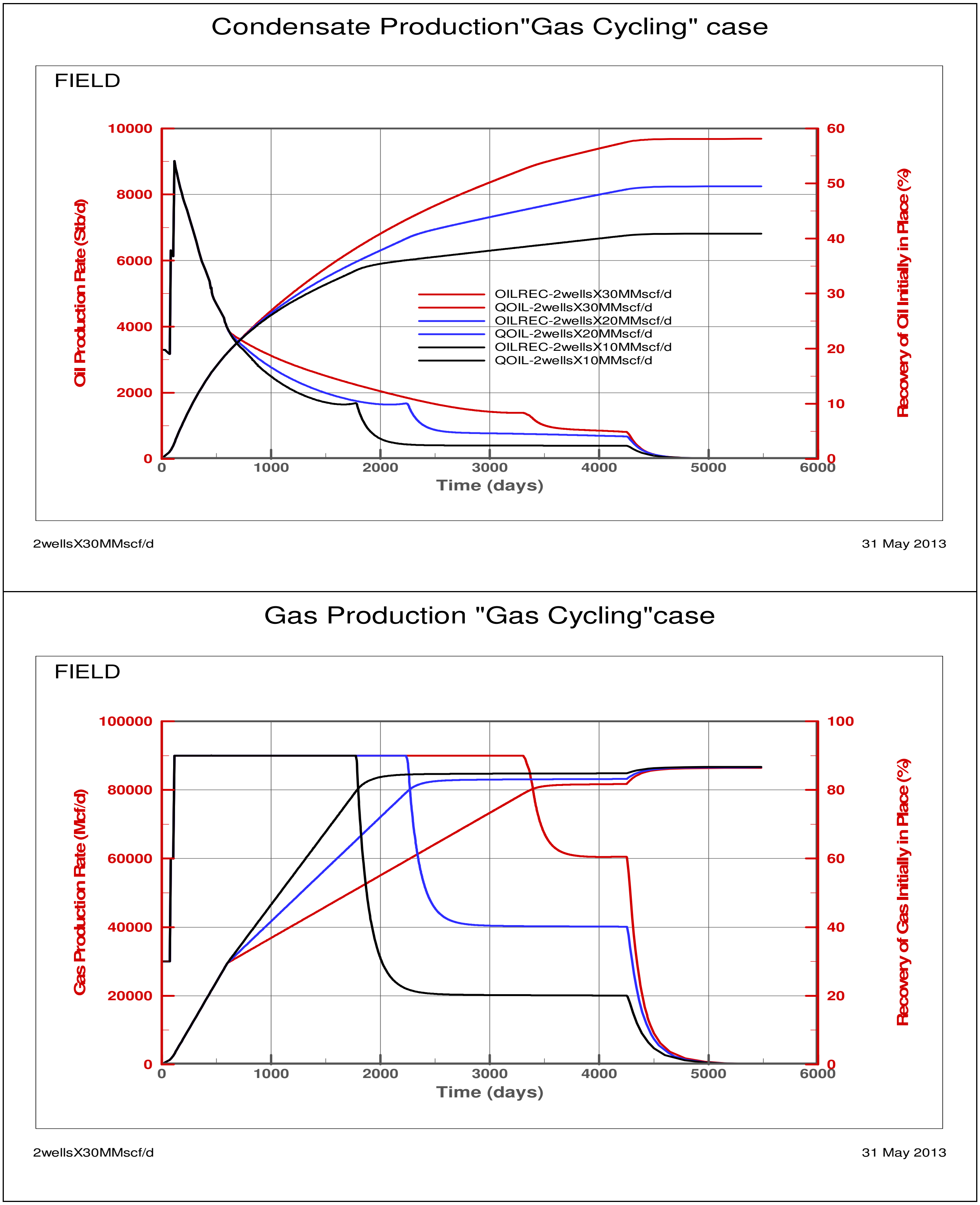


Figure 7 Oil&Gas Production "Gas Cycling"

Reservoir composition model has been run with four injection wells. Same as in previous cases, nature depletion take place during the first 600 days. Gas cycling takes place in period of 600 - 4250 days. In period of “gas cycling” the reservoir pressure maintained by injection “lean” gas. From the Figure 8, the reservoir is sharply depleted in first 600 days then reservoir pressure maintained by gas injection therefore the reservoir depletion occurs slightly.

In case of massive (4wellx3000Mscf/day) gas injection, reservoir pressure increased in period of 600 days to 2700 days and then holds constant equal to dewpoint pressure. That is happening because of vaporizing gas drive mechanism is taking place. The lean gas is “first contact” miscible with reservoir fluid. Thus, fluid displacement by the “first contact” lean gas injection is much efficient in compare with “multi contact” C/V (condensing/vaporizing gas drive) due to IFT=0 (interfacial tension).

Total condensate production, presented on Figure 10 “massive gas injection”, is increased due to VGD mechanism (IFT=O) then slightly decline at the period of 600 to 5480 days. For the same period, condensate production for another case is constantly decline up to 4250 days then production significantly falls due to reservoir blowdown. Condensate ultimate recovery factor for the “massive gas injection” is sharply increased in compare with other gas cyclic strategies and riched 90% due to IFT=0 VGD gas displacement.

From the Figure 10 gas cycling strategy is constrained by the filed gas production capacity. The consequence of that is drainage strategy does not influence for ultimate gas recovery factor.

Field GOR is constantly raised is presented on Figure 9. Comparing with depletion case GOR is raised slowly.

Summary for the Gas Cycling case:

1. Reservoir pressure maintained by injection “lean” gas
2. Condensate production enhanced due to VGD and C/V drive mechanisms.
3. VGD (IFT=0), the Ultimate Condensate recovery riches 90%
4. Condensate composition determine the MMP and MME.
5. Gas Cycling does not enhanced the gas production.
6. Gas cycling is constrained by the field gas production performance.
7. GOR raised slowly then in Depletion case

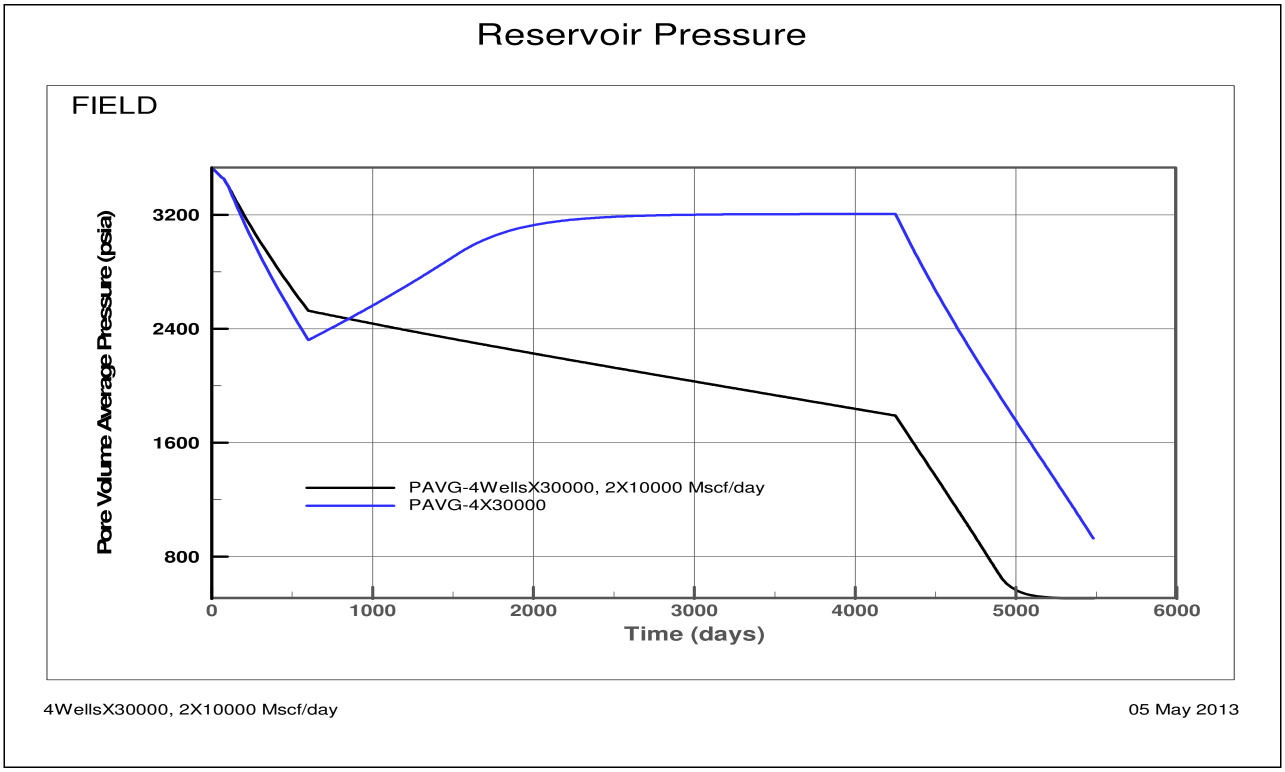


Figure 8 Pore Volume Average Pressure "Gas Cycling" case

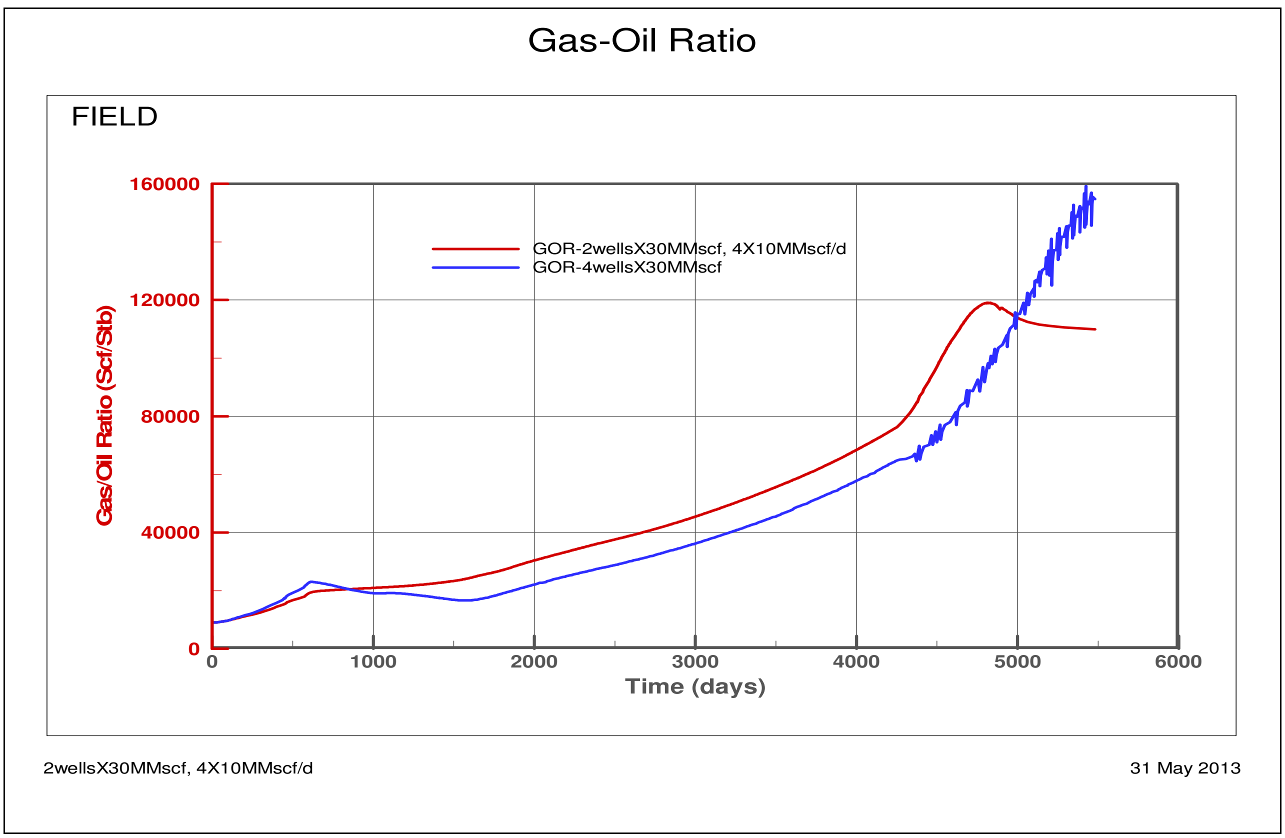


Figure 9 Gas/Oil Ratio "Gas Cycling"

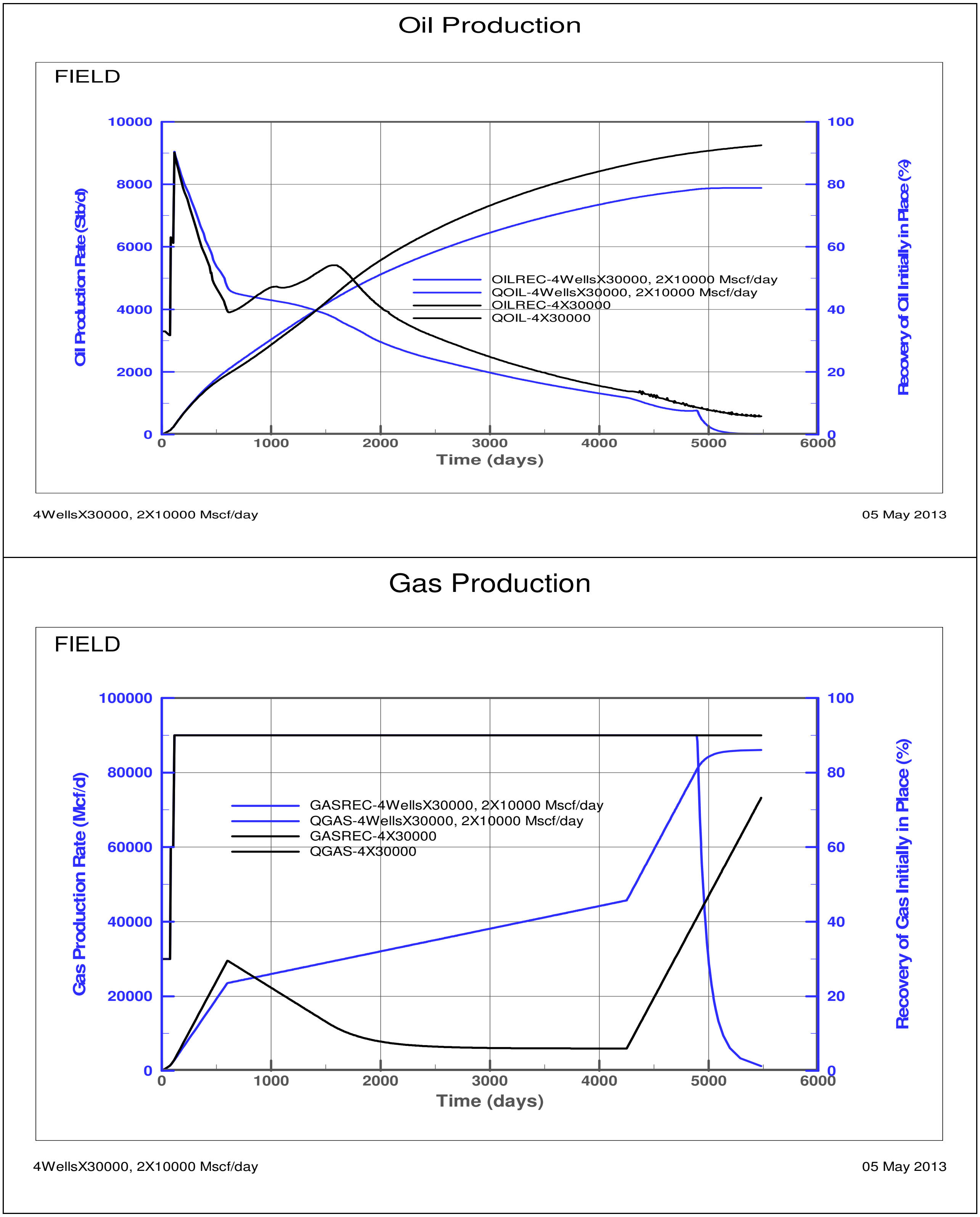


Figure 10 Condensate and Gas production "Gas Cycling" case

Development Strategy Scenario:

Development strategy for gas-condensate production has been chosen the "mixed" one based on "Depletion" and "Gas Cycling" summaries. Development drainage strategy is based on the depletion during the first 600 days, gas cycling (2 injectors - 30000Mscf/d) – from 600-2750 days, massive gas cycling (4 injectors – 20000Mscf/d) – from 2750-4250 days and the blow down – from 4250-5480 days.

Figure 11 is representing reservoir pressure for the observed scenarios. During whole production time reservoir pressure for the chosen development strategy is slightly decreased. For the blowdown period (4250 – 5480 days), reservoir pressure significantly falls down.

Figure 13 is representing the efficiency of the chosen drainage strategy. High ultimate recovery for the condensate 60% is riches because of the most retrograde area is swept by the injection "lean" gas. The condensate production mechanism is condensing/vaporizing (C/V).

Figure 14 is showing gas production performance. Gas production is riches the planned field rate (FGPR=90000Mscf/d) in first 100 days. The plateau takes the most of the production time. The ultimate gas recovery is 84%.

Field GOR is constantly raised is presented on Figure 12 **Error! Reference source not found.** Comparing with depletion case GOR is raised slowly. Cumulative asset productions are presented in Upstream Appendix on Figure 40, Figure 41and Figure 42.

Summary for development strategy scenario:

1. Reservoir pressure maintained by injection "lean" gas, depletion occurs slightly.
2. Condensate production enhanced by C/V drive mechanisms.
3. Ultimate Condensate recovery riches 60%
4. Condensate composition determine the MMP and MME.
5. Gas Cycling does not enhanced the gas production.
6. Gas cycling is constrained by the field gas production performance.
7. GOR constantly and slowly increased.

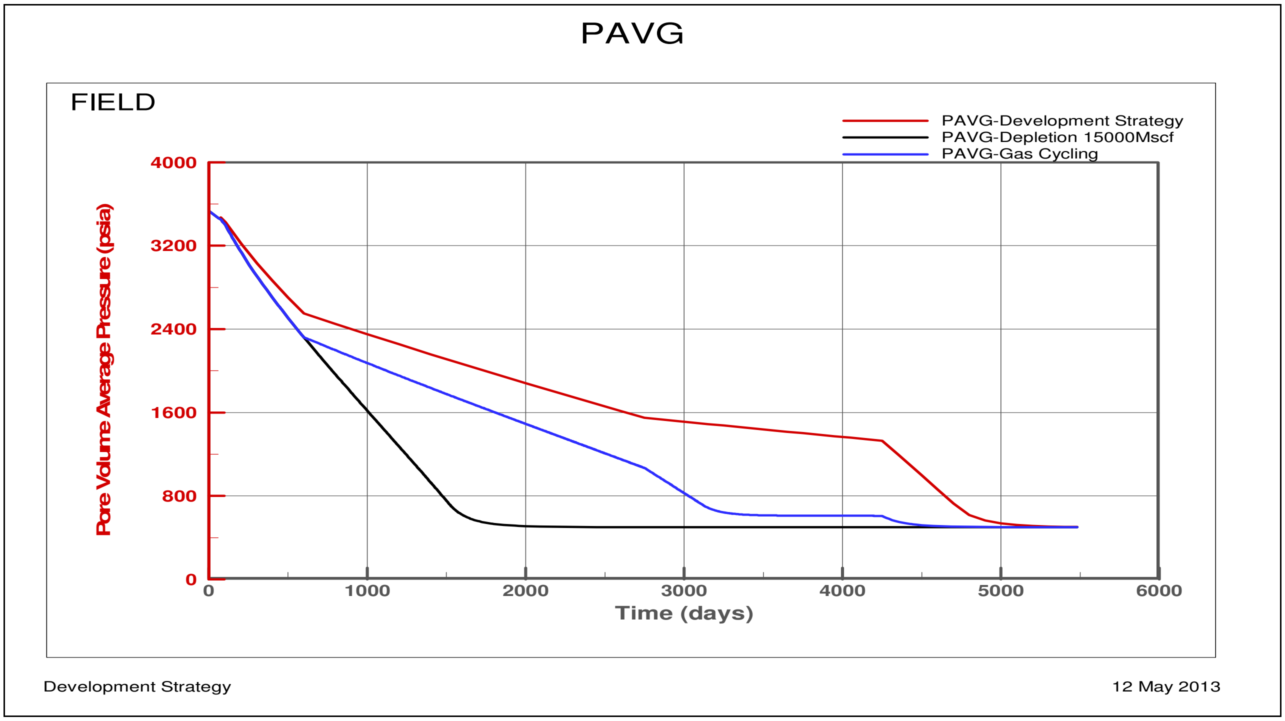


Figure 11 Reservoir Pressure "Development Strategy"

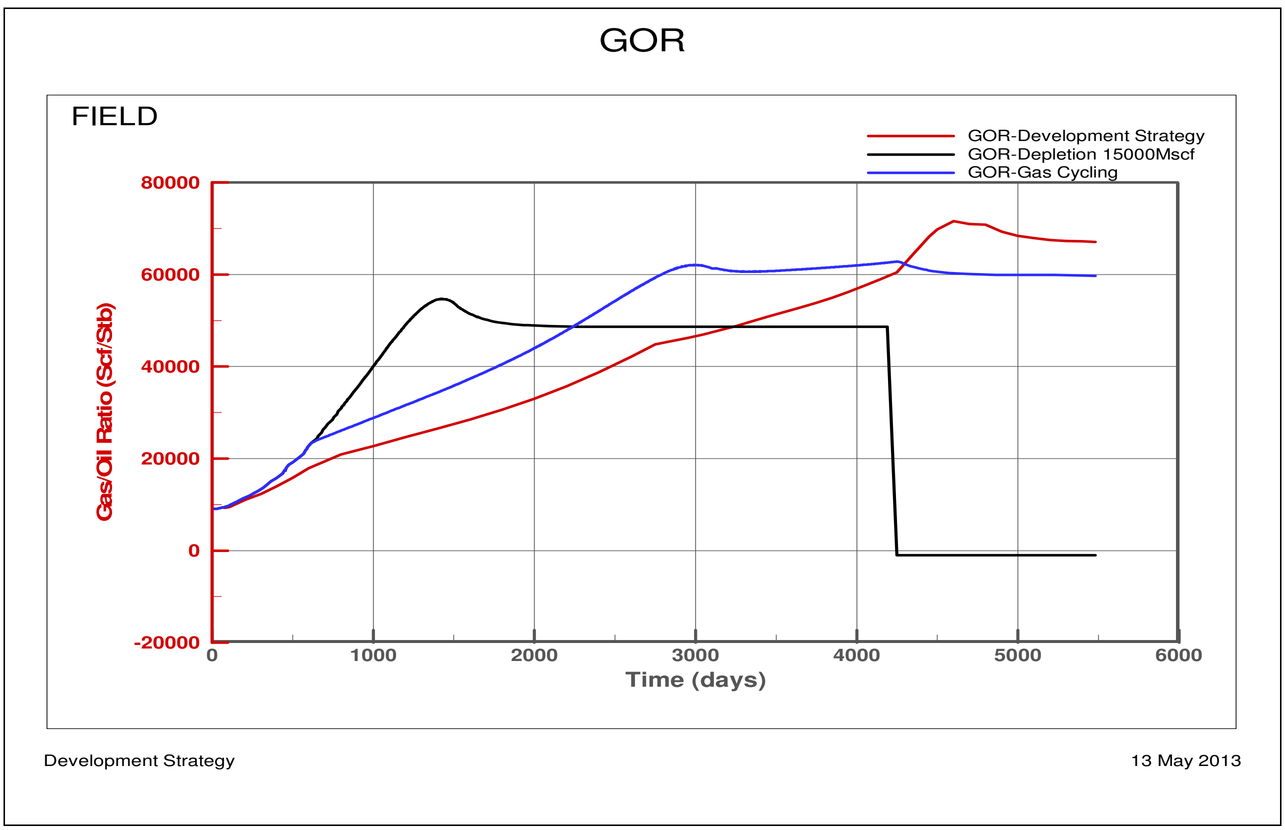


Figure 12 Gas/Oil Ratio

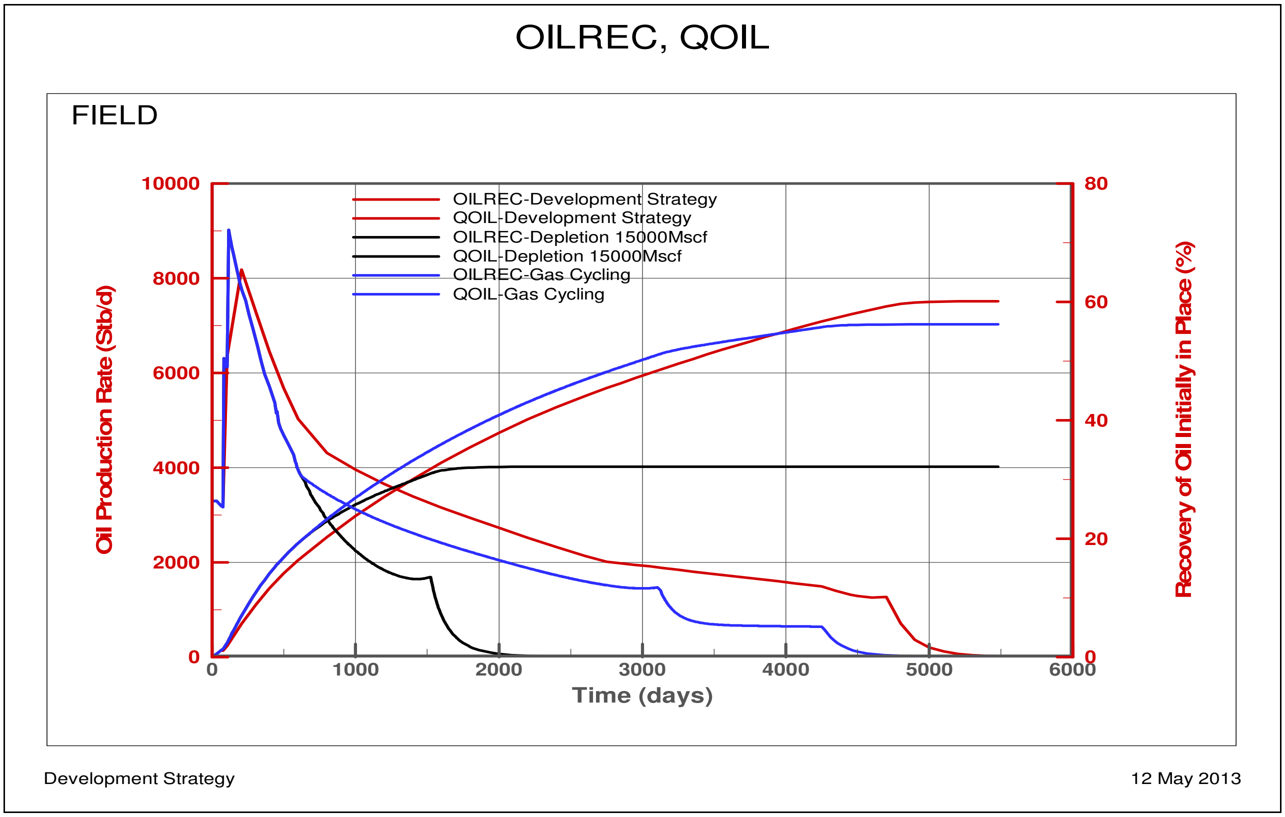


Figure 13Condensate Production “Development Strategy”

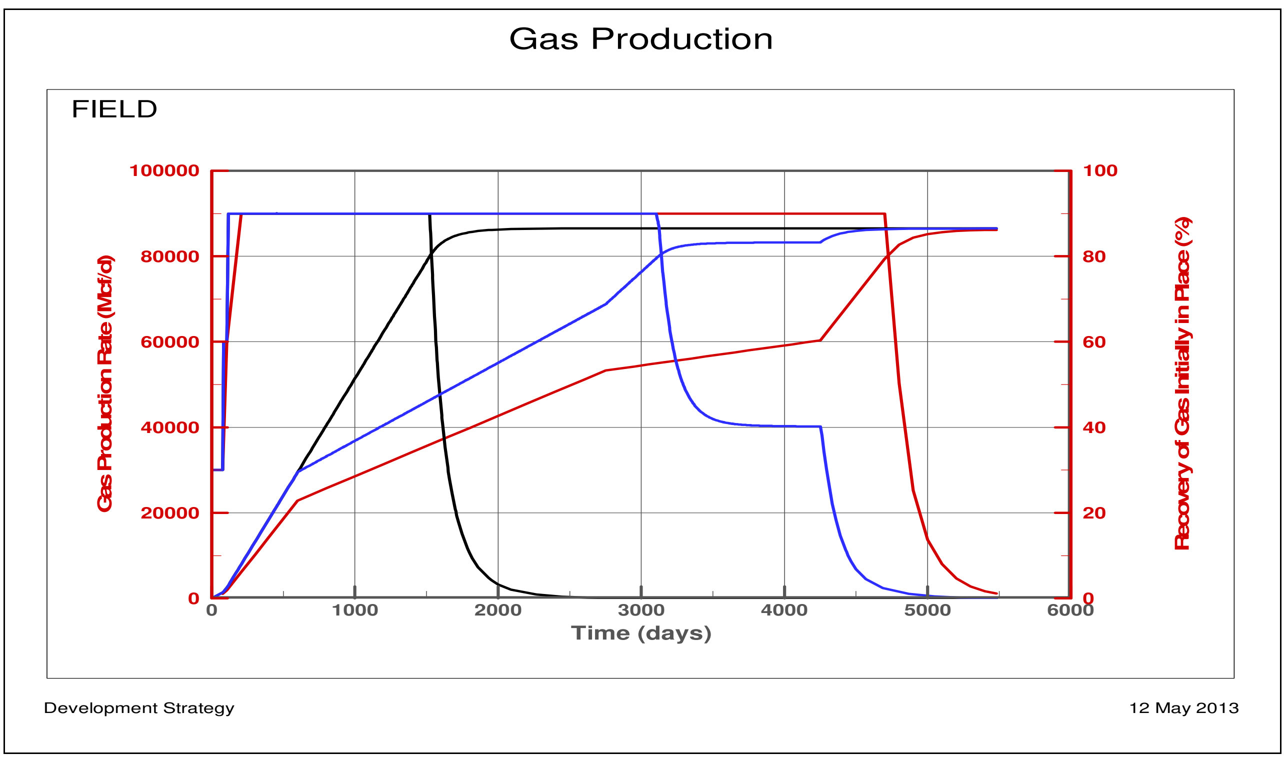


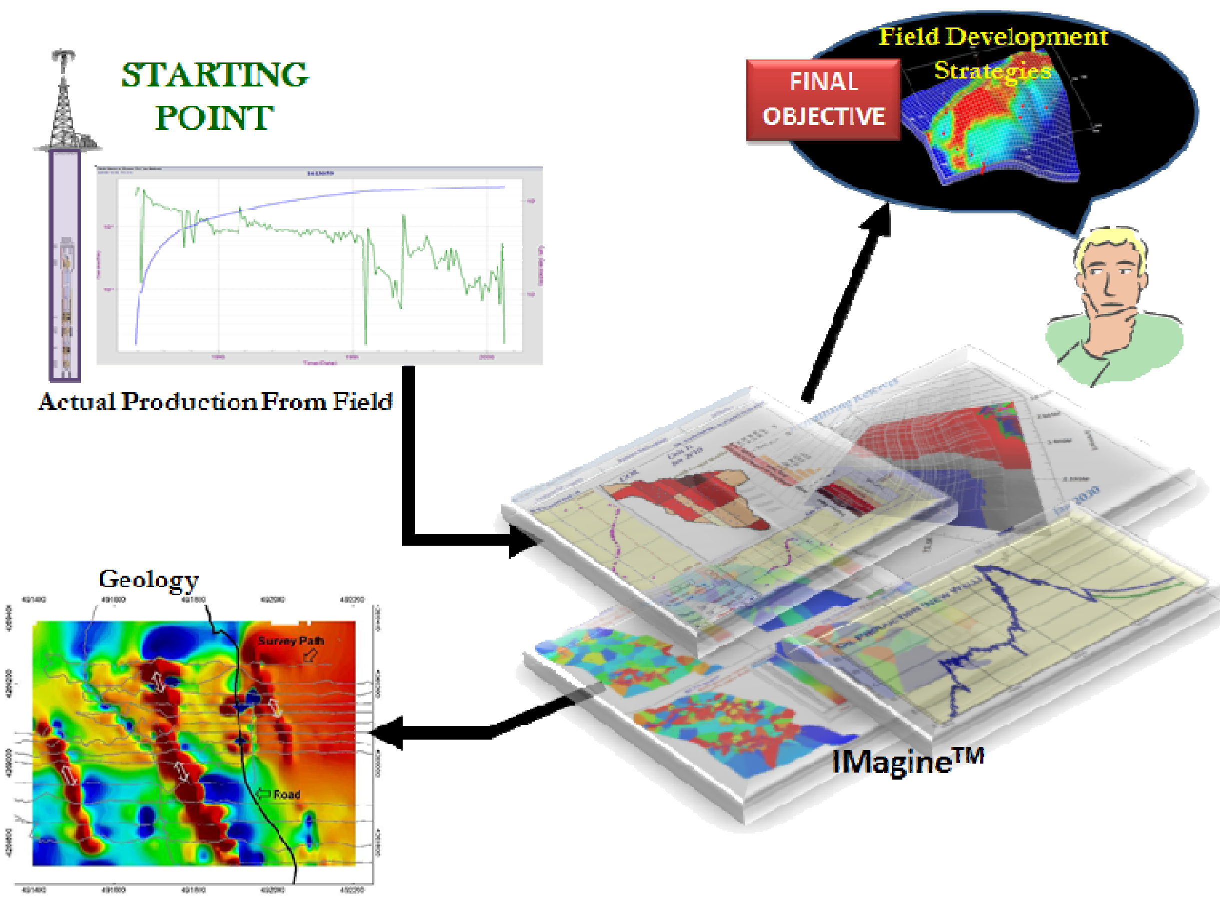
Figure 14Gas production “Development Strategy”

Midstream

Introduction

Midstream simulation is one an important application in the Petroleum Industry, particularly for the field development and asset-management evaluation. Production strategy, forecasting, wells performance analyzing, multiphase flow assurance and assets evaluation are valuable application in production simulation techniques. Picture below shows the midstream applications.

The object for midstream modeling is to evaluate the optimal production strategy for the gas-condensate reservoir. Well and pipelines designing used to take into consideration the common problems occurring in gas production. Define and apply the production strategy to deliver the gas production assets from the reservoir to the surface process facility.



Model

Figure 15 is presenting the steady state midstream model. The model has been developed for the gas-condensate natural production. Model is composition and consists of six identical production and four injection wells. All the wells are vertical. The model specification for the initial steady state case is presented in Table 4.

Producers interacts with the upstream “gas condensate reservoir” using the PI inflow production performance. Production wells are choke equipped. The wellheads connected with manifold through the flowlines, further to sink. “Olga S-2000 V6 2.7-3-phase” flow correlation has been chosen for the vertical and horizontal flow. (Schlumberger, 2011)

Midstream model has been designed symmetrically in order to increase flexibility of simulation and optimization process.

PVT

Fluid composition and PVT characteristics were taken from the upstream (reservoir) study. The initial composition is presented in Table 2 and Table 3. Peng-Robinson equation of state has been chosen as fluid package in the midstream model. (Schlumberger, 2011)

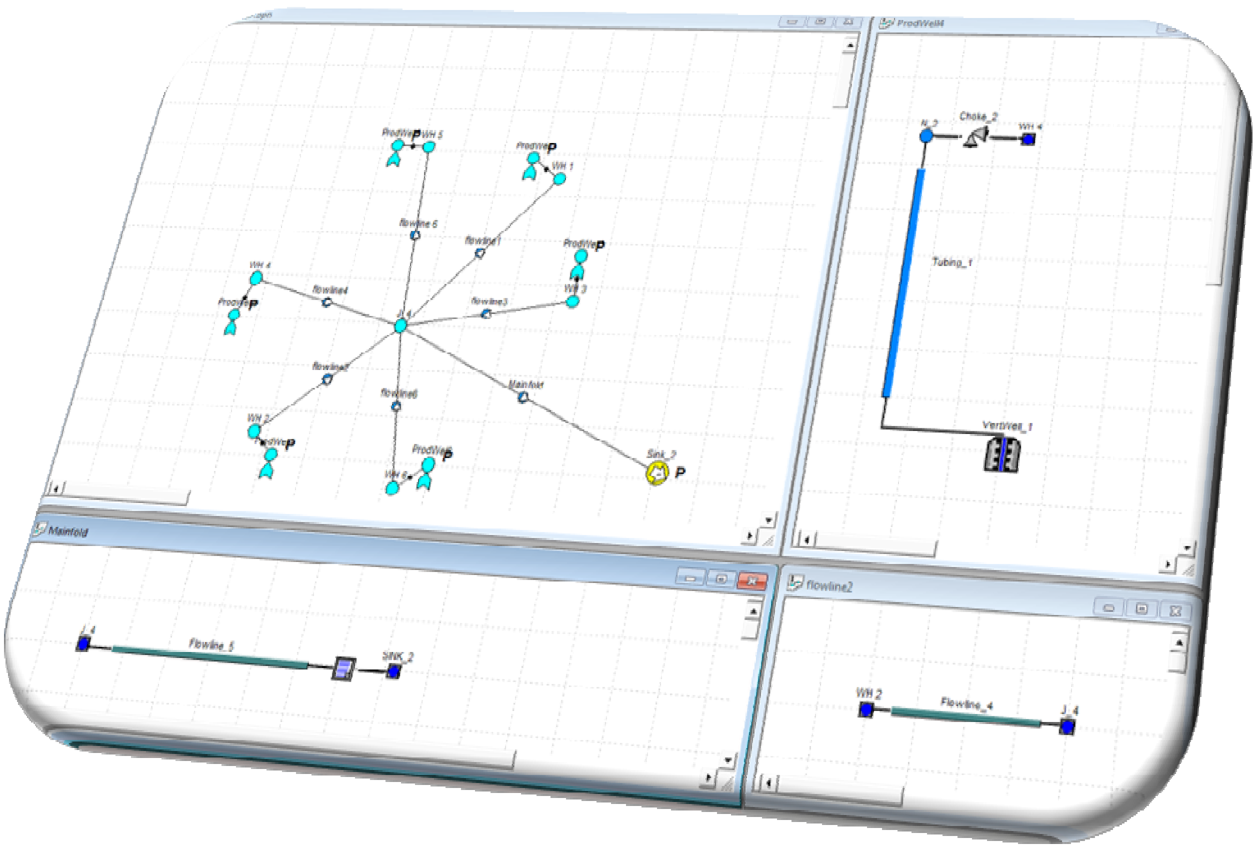


Figure 15" Midstream Model"

<table>
<tr><th rowspan="2">Wells</th><th rowspan="2">IPR</th><th>Pres</th><th>Tres</th><th>Tubing ID</th><th>Casing</th><th>Choke</th><th rowspan="2">Flow line</th><th>ID</th><th>Tamb</th><th>Length</th></tr>
<tr><th>psia</th><th>F</th><th>inch</th><th>inch</th><th>inch</th><th>inch</th><th>F</th><th>ft</th></tr>
<tr><td>Prod.Well1</td><td>PI</td><td>3550</td><td>200</td><td>7.125</td><td>9.282</td><td>0.6</td><td>Flowline1</td><td>4</td><td>50</td><td>984.25</td></tr>
<tr><td>Prod.Well2</td><td>PI</td><td>3550</td><td>200</td><td>7.125</td><td>9.282</td><td>0.6</td><td>Flowline2</td><td>4</td><td>50</td><td>984.25</td></tr>
<tr><td>Prod.Well3</td><td>PI</td><td>3550</td><td>200</td><td>7.125</td><td>9.282</td><td>0.6</td><td>Flowline3</td><td>4</td><td>50</td><td>1640.4</td></tr>
<tr><td>Prod.Well4</td><td>PI</td><td>3550</td><td>200</td><td>7.125</td><td>9.282</td><td>0.6</td><td>Flowline4</td><td>4</td><td>50</td><td>1968.5</td></tr>
<tr><td>Prod.Well5</td><td>PI</td><td>3550</td><td>200</td><td>7.125</td><td>9.282</td><td>0.6</td><td>Flowline5</td><td>4</td><td>50</td><td>1968.5</td></tr>
<tr><td>Prod.Well6</td><td>PI</td><td>3550</td><td>200</td><td>7.125</td><td>9.282</td><td>0.6</td><td>Flowline6</td><td>4</td><td>50</td><td>1640.4</td></tr>
</table>

Table 4 Wells and Flow lines Specification

Liquid Loading "Critical Gas Rate"

Liquid loading is a common problem during the gas production. The water and condensate (heavy components) develops from gas-condensate in reservoir, well and pipelines due to pressure – temperature reduction. The liquid could not be produced to the surface falls back and accumulates at the well's bottom due to gravity. Thus, the consequence of the liquid loading could restrict the gas production and in some cases even kill it. (Schlumberger, 2011)

Liquid loading phenomena creates a significant back pressure therefore rich gas-condensate production rate restricted. One of the ways to predict liquid loading onset is determining the "Critical Gas Rate". This criterion is a valuable production parameter to avoid the liquid loading onset during the gas-condensate production strategy. (Schlumberger, 2011)

"Critical Gas Rate" has been determined using the convectional approach (Nodal analyze) to combine the steady state or pseudo steady state reservoir performance (IPR) with the steady state or pseudo steady state well performance (TPR). "Critical Gas Rate" is defined as a minimum or critical gas rate that would sustain the liquid production. (Schlumberger, 2011)

During the production time reduction of wellbore conditions (P, T) and various fluid compositions were taken into account to determine the "Critical Gas Rate". Figure 16 presenting the critical gas rate for the whole production period. Gas production rate = 11.4 MMscf/d is a critical rate that could sustain the liquid unloading.

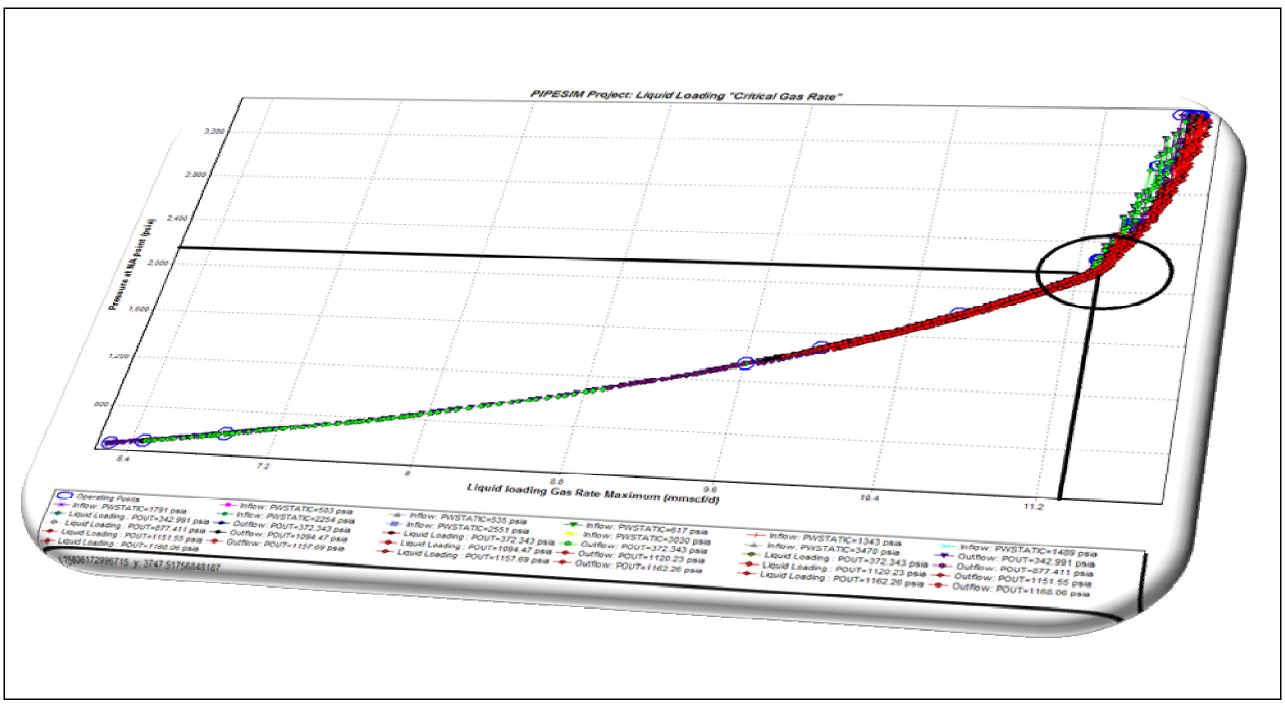


Figure 16 " Critical Gas Rate"

Optimization (Choke)

The field model has been designed to develop the gas-condensate reservoir in 15 years as a midstream application. Development strategy, defined in upstream part, has been used as a feed to define the production strategy.

Production wells are choke equipped. Optimization has been done to define the gas-condensate production strategy, determine wellhead, bottom whole pressure and composition.

Optimization variable parameter is Choke ID. Boundary conditions for the model are reservoir pressure and sink pressure. Local and global constraints are presented in Table 5 Model Optimization Constraints. Optimization process has been done manually due to model requirements.

Node	Local/Global Constraint		
	Pressure, psia	Gas Rate, Mscf/d	Choke, inch
Wells	Reservoir Pressure	Production Rate	Choke ID
Flow lines	Estimate Pressure	Estimate Rate	
Manifold	Estimate Pressure	Estimate Rate	
Sink	Pressure	Total Rate	

Table 5 Model Optimization Constraints

Result

Figure 18 presenting the production strategy for the midstream. Result of optimization is a series of steady state solutions for the whole period of gas-condensate production.

Well head pressure and choke positions have been defined for the production wells. Result of optimized THP pressure and choke positions are depicted on Figure 17.

Total field gas production (FGPR) presented on Figure 18, riches the planned production rate of 90 MMscf/d in first 100 days. The plateau production is more and less the same for both simulators (SENSOR and PIPESIM) in period of 0 – 3750 days. Then FGPR starts rapidly decline in compare with SENSOR's result. That is happening because of the reservoir pressure will not able to sustain the planned field gas production rate. Thus, the reasons are "liquid loading" and the pipeline's specification (P, T). The pipeline network specification and configuration plays an important role in production strategy. Development model defined in upstream controlled by the separator (P, T) conditions in order to define cycling gas composition. Upstream model does not observe the midstream therefore booster station has been introduced to sustain planned assets production. Difference in reservoir and wellhead pressure sustain multiphase deliverability are shown on Figure 18 and Figure 19. Production stream is shown in Table 6, represent production strategy from reservoir to process facility.

Typical PIPESIM output file is presented in Table 10. (Schlumberger, 2011)

Component	mol %									
Time, days	120	480	840	1200	1800	2640	3840	4680	4920	5480
CO2	1.21	1.23	1.11	1.13	1.20	1.26	1.20	1.31	1.31	1.20
N2	1.95	2.07	2.17	2.21	2.08	1.96	1.66	1.95	1.95	1.77
C1	66.06	68.93	67.69	69.04	68.64	67.89	60.67	68.42	68.42	62.46
C2	8.67	8.63	7.19	7.26	8.08	8.98	9.04	9.80	9.80	9.06
C3	5.88	5.65	4.45	4.36	4.99	5.85	6.46	6.85	6.85	6.42
C4-6	9.60	8.93	8.38	8.06	8.45	9.22	10.96	10.31	10.31	9.79
C7+1	4.63	3.45	7.02	6.26	5.25	3.76	7.45	0.91	0.91	0.88
C7+2	1.49	0.94	1.63	1.32	0.97	0.72	1.59	0.11	0.11	0.10
C7+3	0.30	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
H20	0.23	0.12	0.33	0.34	0.35	0.35	0.98	0.34	0.34	8.33

Table 6 " PIPESIM COMPOSITION"

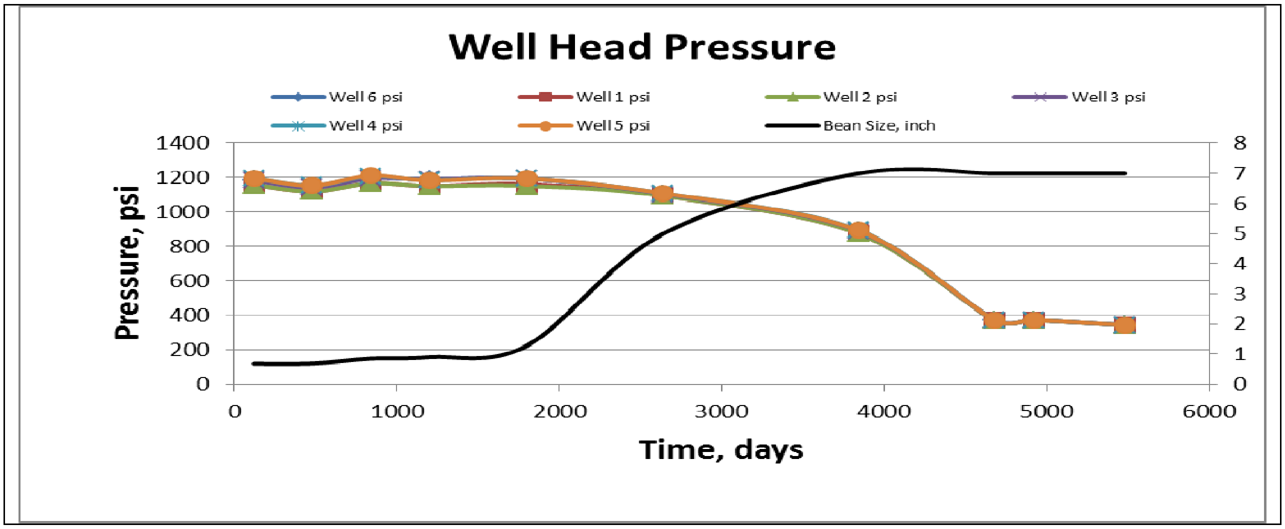


Figure 17 "Optimization Pwh, Choke ID"

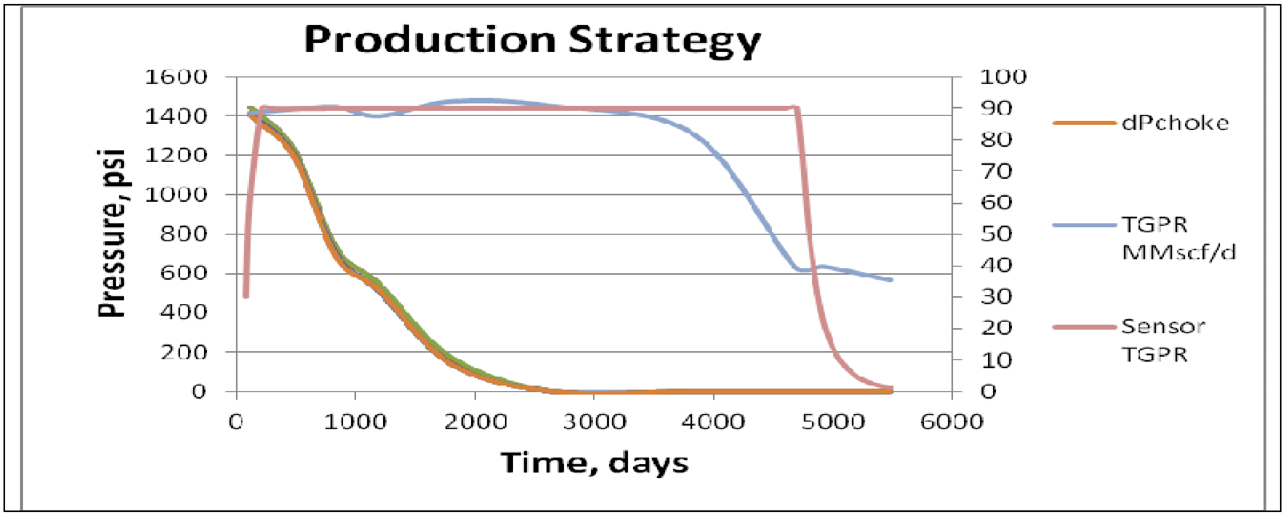


Figure 18 "Production Strategy."

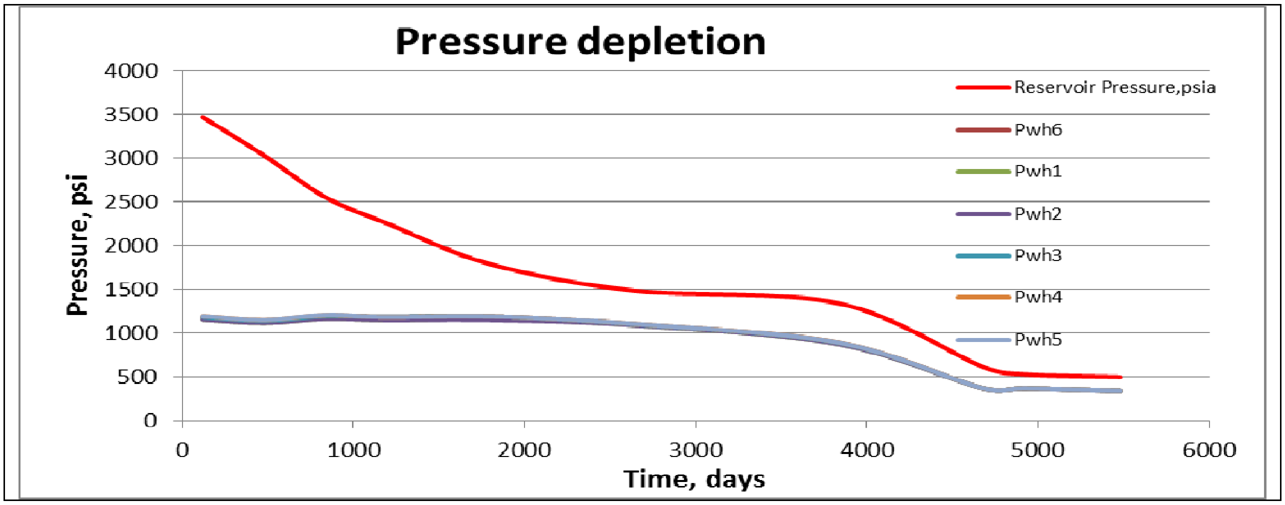


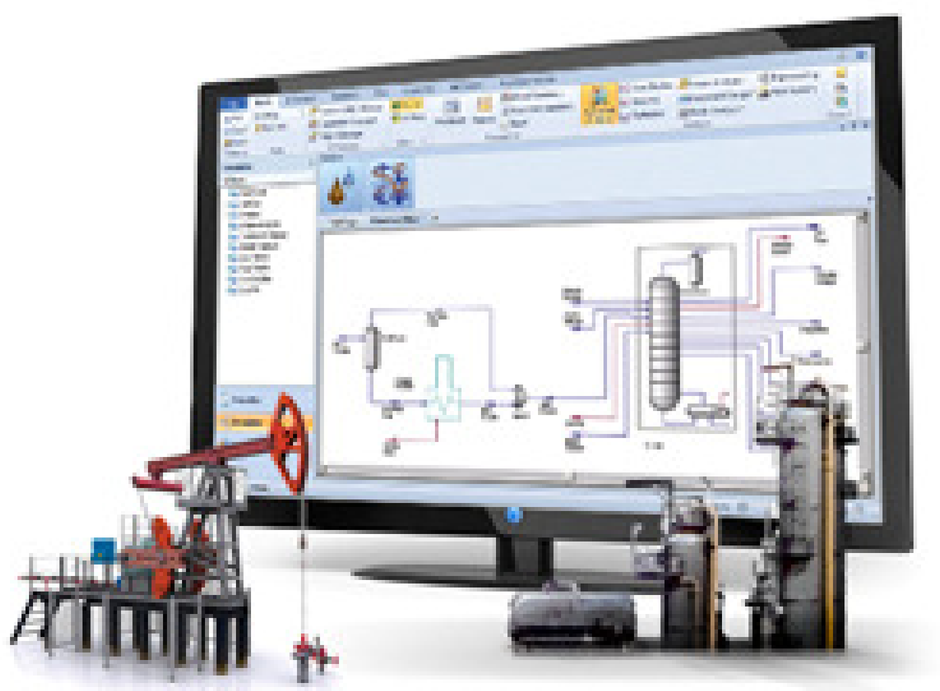
Figure 19 "Well Head Pressure Depletion"

Downstream

Introduction

Downstream model is a pre-market treatment stage. Process simulation is one an important and fundamental application in the Petroleum Industry for asset-management evaluation. Separation, dehydration, CO2 absorption, NGL and Cascade LNG extraction are sensible and valuable application in process simulation techniques. Picture below characterized the complexity of the process simulation applications.

The object of downstream modeling is fluid assets evaluation. Complexity of the treatment processes and facility required separate process observation and specification. (Aspen Technology)



Model

Downstream thermodynamic, steady state model has been developed for the gas-condensate production. Downstream application is an extension of the gas-condensate field development. Model is composition consists of 11 components, Peng-Robinson equation of state (EOS) has been chosen as a fluid package. Upstream and midstream composition stream fed in downstream model. Figure 20 presenting processed valuable production assets.

Thermodynamic, steady state model consists of Separation Unit, Dehydration Unit, CO2 Extraction Unit and simplified NGL&LNG Unit. Process units are presented on Figure 21 and explained below.

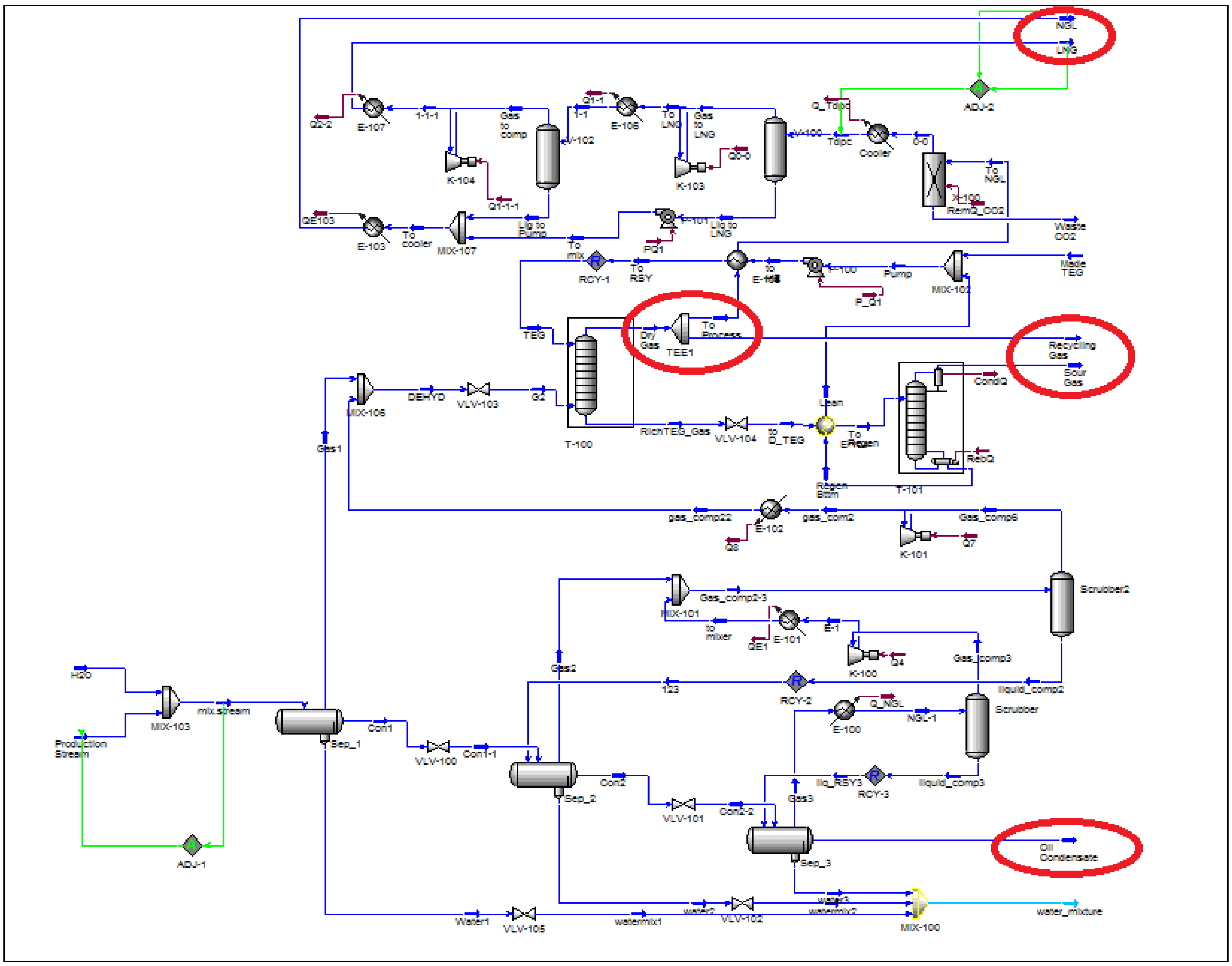


Figure 20 HYSYS Model

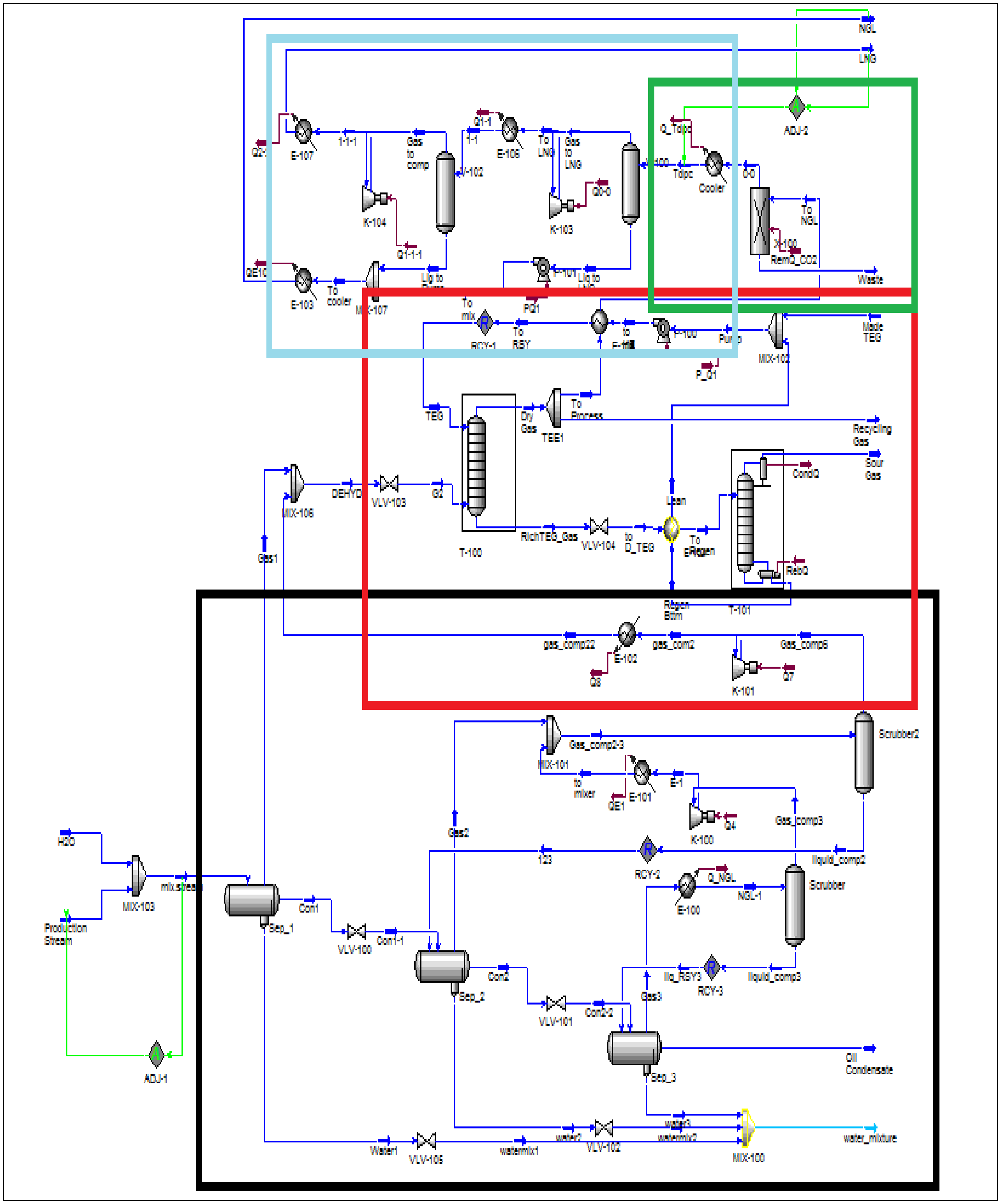


Figure 21 "HYSYS UNITS"

Separation Unit

Separation unit is shown in black quad shown on Figure 21 “HYSYS UNITS”. The unit consists of the rotating and static-mechanic equipment. Rotating equipments are pumps and compressors. Separators, scrubbers, mixers and coolers are static-mechanic equipment. (Aspen Technology)

Obviously, separation process is a first stage of the gas treatment process and plays an important role in gas-condensate assets production. Gas treatment unit consists of three stage separation process. The type and specification of the static equipment is shown in Table 7.

Separator	P, psia	T, F
3-phaze, horizontal-1	805	80
3-phaze, horizontal-2	60	34.23
3-phaze, horizontal-3	14.7	17.4164

Table 7 "Separator specification"

Upstream gas-condensate stream is fed to the first stage of separation process. Gas, condensate and water are separated at the first stage. Separated gas assigned to dehydration unit. Separated water directed to water disposal station. Condensate is fed to the second stage and so on. Condensation process normally starts in the well and flowlines due to pressure and temperature reduction. Bulk water separated on each stage of separation process. Separated water is directed to the water disposal station.

Condensate, separated at first stage, is fed to the second stage of separation process and further to the third one. At each separation stage the light components (C1-C4) are separated from the condensate, due to pressure and temperature reduction. Phase envelope for the steady state condensate separation process is shown on Figure 22 “Phase Envelop Condensate Separation Process”.

Separated gas, from the last stage of separation process, is cooled and fed to the Scrubber where liquid phase 3-5% separated to protect compressor station. Liquid phase directed to the third separator where the liquid phase mixed with condensate stream to enhance condensate recovery. Only one way to get the dewpoint specification for mixing separated gases is compressing and cooling. Gas from the scrubber is compressed and cooled in order to obtain same dewpoint condition as gas separated from the second separator. Those gases are mixed and direct to the scrubber to avoid the liquid phase. Liquid phase occurred when gas was cooled, is separated and directed to the second separator. Further gas is compressed and cooled to get the same dewpoint condition as gas separated from the first separator. Processed gas is mixed with gas from the first separator and directed to dehydration unit. Dewpoint specification for the steady state gas separation process is shown on Figure 23 "Phase Envelope Gas treatment process".

The liquid (heavy hydrocarbons + H20) separated from the Scrubbers are fed back to the separators in order to enhance condensate extraction.

Dehydration Unit (TEG)

Dehydration Unit is shown in red quad on Figure 21 “HYSYS UNITS”As it mentioned above the water removal process starts in the wells, flowlines and further in separation unit. Separated natural gas contains the water. To avoid hydrate and corrosion problems that would occur in further process, the water fraction should be removed from the feed. The process called “Dehydration”. (Aspen Technology)

Strict dewpoint specification for gas used as a feed to LNG and NGL extraction unit required to remove bulk water.

In principle there are three main processes are used to remove bulk water from natural gas:

- Expansion and Separation
- Absorption (MEG, DEG and TEG)
- Adsorption (solid material)

The “Expansion and Separation” and “Absorption” were used in the model. The typical Peng-Robinson (PR) equation of state was used for it.

Note!!! Normally PR will give a bad result especially at high pressure due to water is a polar substance and creates hydrogen bounding. (Arne Fredheim, Even Solbaa, 2012)

In order to obtain dry gas dewpoint specification, separated “wet” gas is fed into the bottom of absorber. Lean TEG (“three ethylene glycol”) is feed at the top of the absorber contractor. Specification of the absorber is shown in Table 8. Wet natural gas is flowing upwards in absorber column at the same time as lean TEG run down. The mass transfer process is taking place due to affinity glycol to water properties. Water content is reduced from the top of the absorber. Dryness efficiency of the gas is depended on TEG concentration on the upper tray. (Arne Fredheim, Even Solbaa, 2012)

As the TEG flows down in the absorber, the water fraction is increased. The rich TEG is sent to the distillation column where the rich TEG is re-boiled at low pressure and high temperature. High temperature used in order to increase the process efficiency. Hot, re-boiled TEG pumped back to absorber through heat exchanger, where hot TEG is cooled down by cold rich TEG feed in order to obtain operation condition. TEG circulation rate is depended on operational parameters, water content in the feed gas and the dryness specification. Distillation column specifications are shown in Table 8. Dewpoint specification for dehydration process is presented on Figure 24"Phase Envelop Dehydration Process".

CO_2 Extraction Unit

CO_2 Extraction Unit is shown in green quad on Figure 21 “HYSYS UNITS” The quality of the natural gas stream is very strict especially for the CO_2 fraction 50ppmv. The CO_2 extraction process is similar to the one described above. The process is absorption by circulated MEA (monoethanolamine) or MDEA (methyl-diethanoamine). (Aspen Technology)

The CO_2 Extraction unit has been designed using the “SPLITTER” to avoid the model complexity. Dewpoint specification for CO_2 extraction is shown on Figure 24"Phase Envelop Dehydration Process".

NGL&LNG Production Unit

NGL and LNG production unit is shown in blue quad on Figure 21 “HYSYS UNITS” Simple model of “Cascade liquefaction Process” has been designed. The process required pre-cooling “Propane Cooler”, liquefaction and the sub-cooling stages. (Arne Fredheim, Even Solbaa, 2012)

Natural gas represents a mix of the pure fluids. Liquefaction temperature of these pure fluids is lie on the range from 10 C to -160 C. (Arne Fredheim, Even Solbaa, 2012)

It is very important to note that small pressure drop was detected during the LNG&NGL process.

Obviously, propane C3 is used as a refrigerant for the pre-cooling stage, due to normal boiling point (NBP) is -42 C. Propane can cover the temperature gap from the ambient temperature to -42 C as a refrigerant. Compression train section has been designed in order to modeling liquefaction stage. This section contains from compressors, coolers and scrubbers. Small pressure drop along the train is applied in order to minimize work for liquefaction. Last cooler has been designed to represent sub-cooling stage. (Arne Fredheim, Even Solbaa, 2012)

Pre-cooled natural gas is fed to the scrubber to avoid two phase on the stream. Further gas is fed to the compression train in order to obtain the dewpoint specification of the final product. Liquid (NGL) are separated from the gas feed before and during compression. Further liquids (NGL) are pumped and mixed. To get the stable condition the liquid is cooled. Last cooler represents sub-cooling stage. Feed is cooled up to -160 C. Traditionally Methane, Ethylene and Propane are used to cooled the feed up to -160 C due to NBP of ethylene is -103C, NBP of methane is -161C and NBP of propane is -42C. Thus feed gas can be cooled and liquefied in range from the ambient temperature to the -161C. The final product is LNG and NGL. Dewpoint control for NGL and LNG production is shown on Figure 25 "Phase Envelope LNG&NGL Process".

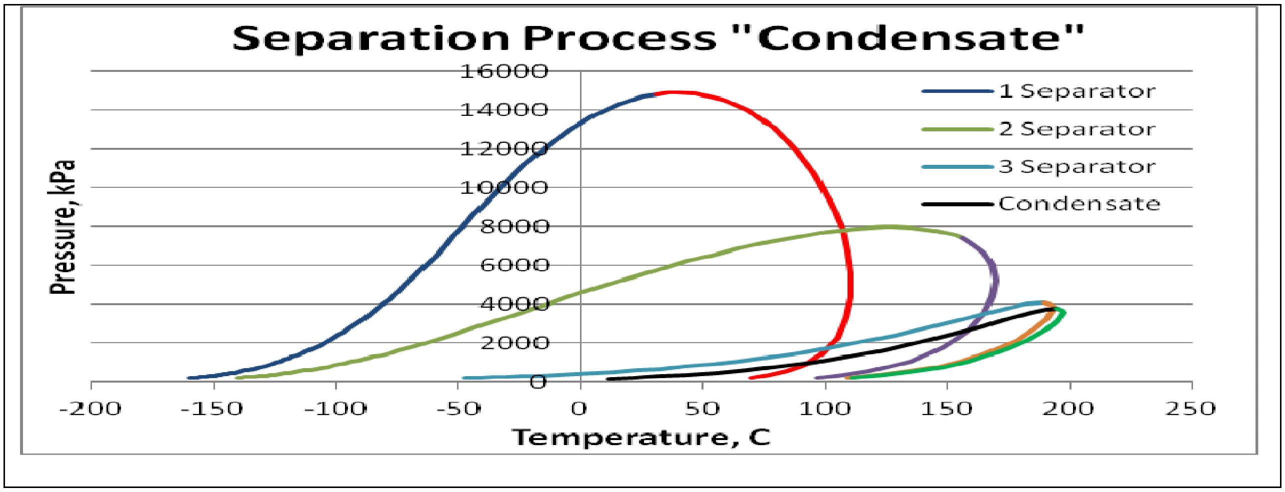


Figure 22 "Phase Envelop Condensate Separation Process"

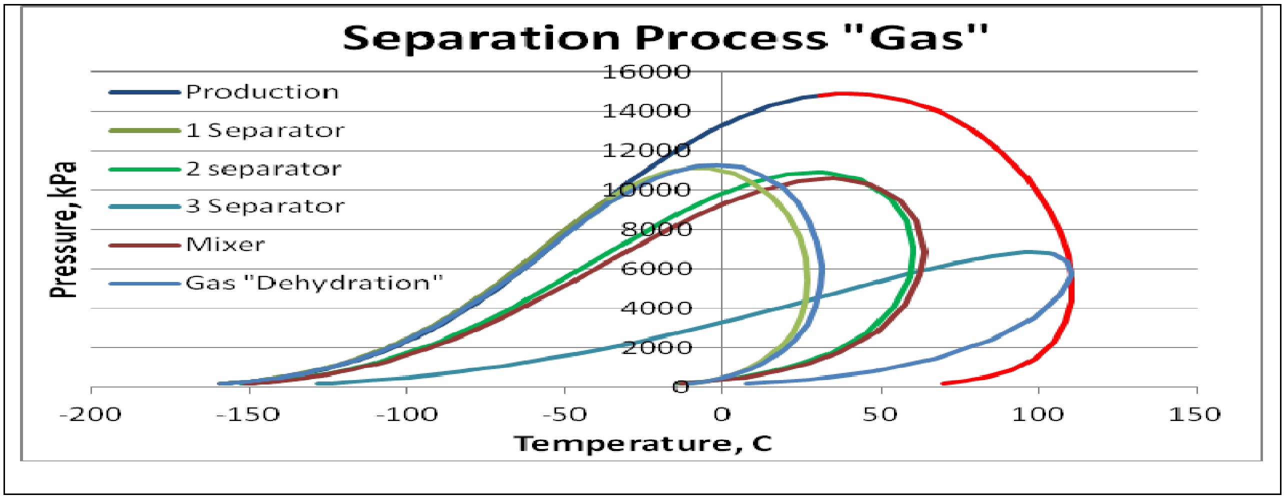


Figure 23 "Phase Envelope Gas treatment process"

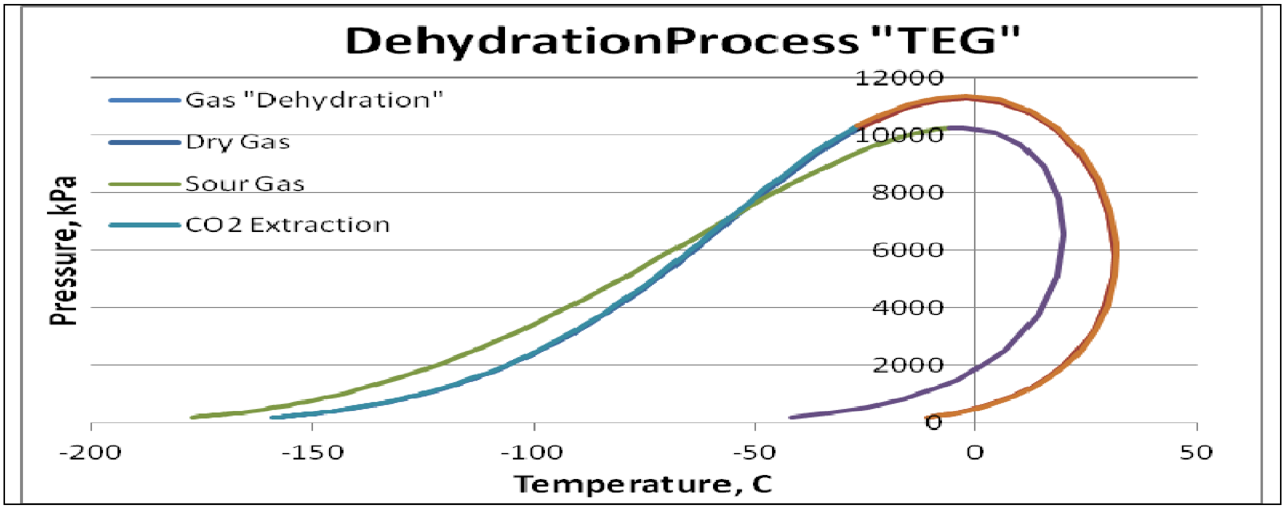


Figure 24"Phase Envelop Dehydration Process"

Contractors	№ trays	Pressure kPa	Temperature C
Absorber	14	5519	21.94
		5519	21.78
Distillation column	10	101.4	101.7
		103.4	204.4

Table 8 "Contractors Specifications"

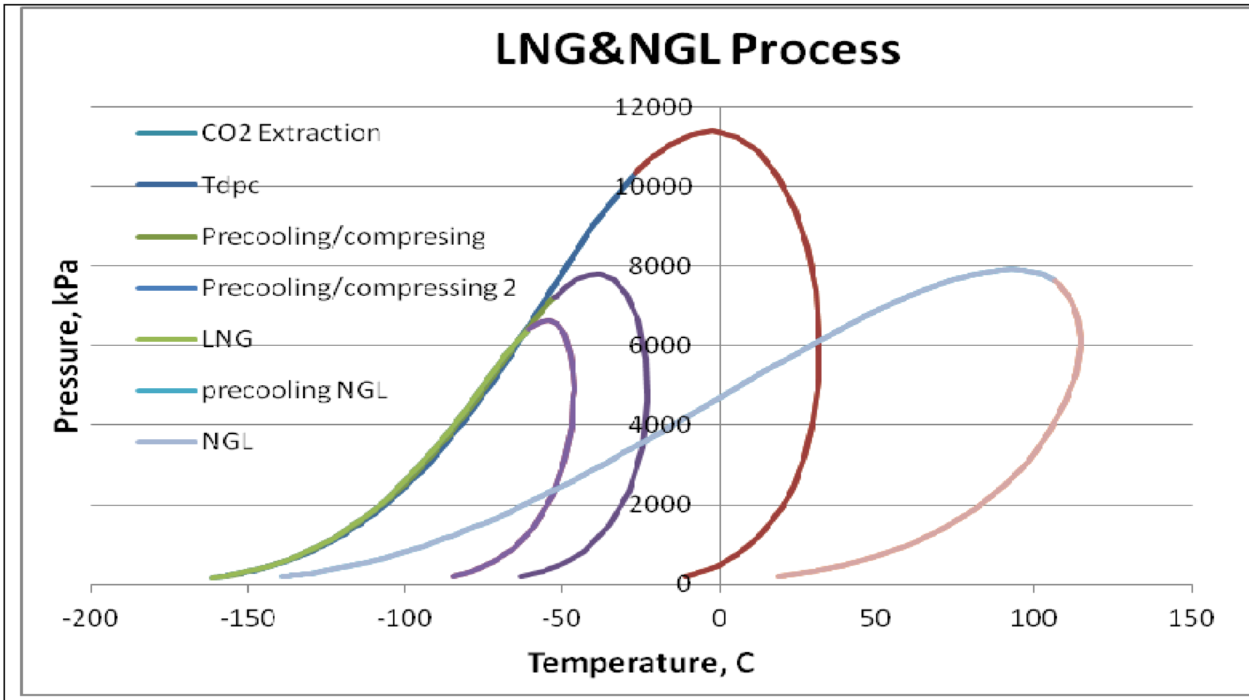


Figure 25 "Phase Envelope LNG&NGL Process"

Optimization

Model has been designed with automatically adjusted “dewpoint control temperature (Tdpc)” presented on Figure 20 HYSYS Model. Adjustable parameter during optimization process is Cooler capacity. In order to enhance LNG and NGL recovery, cooler capacity “Tdpc” has been optimized using the HYSYS optimizer. Variable parameters have been chosen the “Tee fraction” and “Tdpc”. The objective function has been chosen maximization of “Actual Liquid Flow” of LNG stream. Result of optimization is shown in Table 9.

Result

Model has been designed in order to deliver the valuable gas-condensate streams on the market. Those streams are “Condensate”, “NGL” and “LNG”. Steady state compositions of main process streams are presented on Figure 26 "Process SS Result".

Dynamic composition flow of those streams will be explained and presented in Integrated Asset Model “IAM” part.

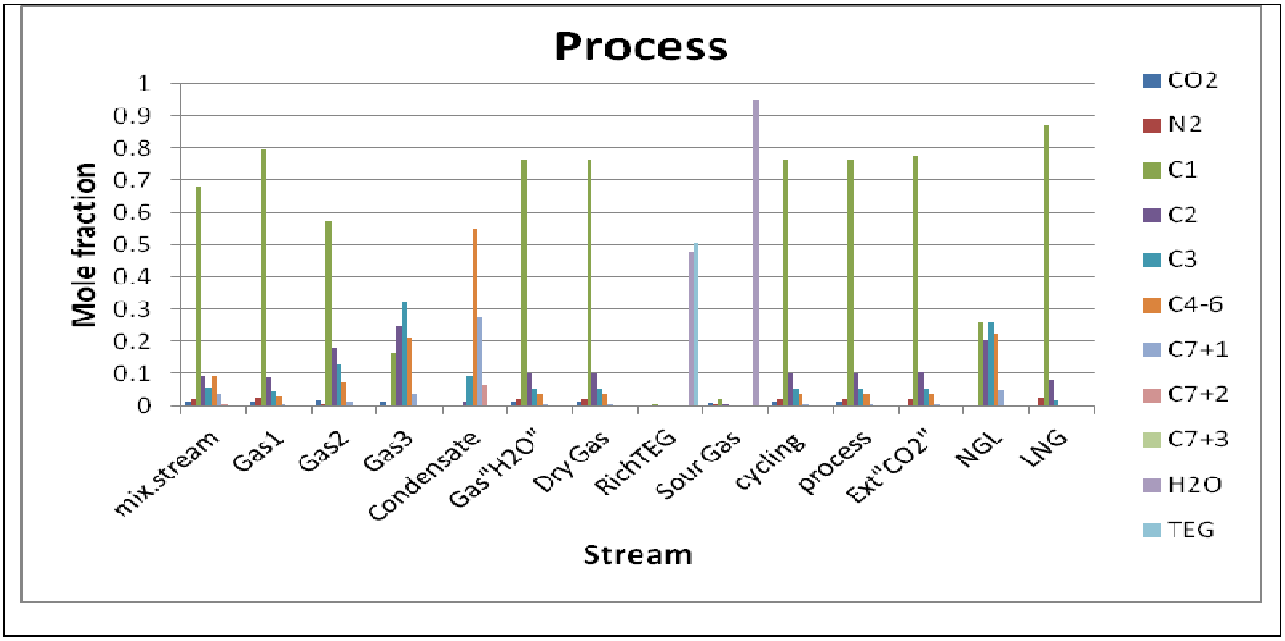


Figure 26 "Process SS Result"

Optimization (LNG flow - maximization)			
Variables	Low Bound	Current	High Bound
Tdpc	-54.73283	-27.4301902	-13.683208
Tee_frac	0	1.00E-06	1

Table 9 "Optimization Result"

Integrated Asset Model "IAM"

Introduction

Integrated simulation and optimization is an important application in petroleum industry especially for the field development strategy evaluation and assets management controlling. Traditionally model consists of upstream, midstream and downstream applications. The effort of such model is whole production chain observation and opportunity for optimization in order to obtain the global maximum or minimum.

Model

Integrated Asset Model "IAM" for the gas-condensate production has been designed on PIPE-IT commercial software. The IAM consists of the Upstream, Midstream and Downstream applications and presented on Figure 27"PIPE-IT Project."

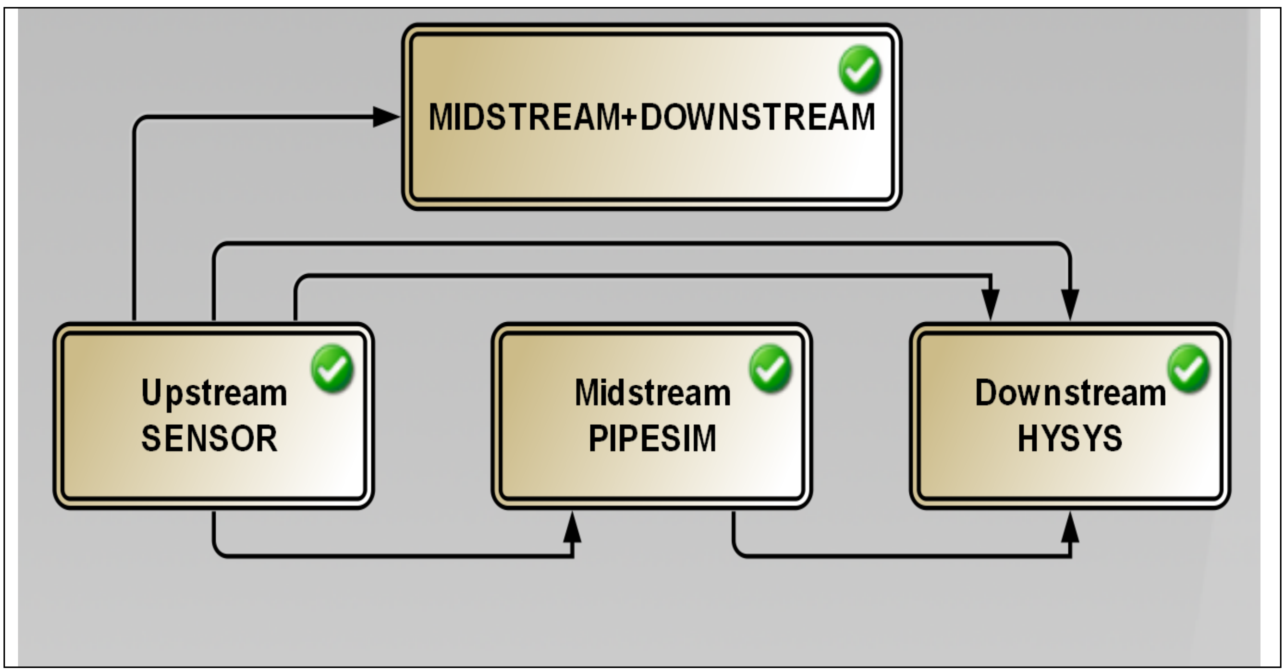


Figure 27"PIPE-IT Project."

IAM is run by integrating the upstream, midstream and downstream models described above. Integration of those models was done using the VBA, VBS and Ruby programming scripts. The VBA and VBS for midstream model integration have been developed by Stein Orjan Solrud. The Ruby script, for downstream model integration, has been developed by Silvya Dewi Rahmawati.

Upstream

Upstream, reservoir development model has been studied in "Upstream" part. The gas-condensate reservoir has been integrated using the PIPE-IT platform. Figure 28 is presenting upstream integration process. Integration was done using a "Resource", which has blue color, and "Process", green color. Resource is initial SENSOR data file and the process – scrip to run SENSOR reservoir simulator.

Running the upstream model, output files create field production-stream file using the "Sen2Str" process. Further the streams file will be sorted by wells and averaged. Composition of producers and injectors are fed to midstream application in order to define production strategy and generate wellheads pressure.

Average field mole production stream is fed to the downstream application. Stream contains of average production time and average mole production of the 9 components fluid.

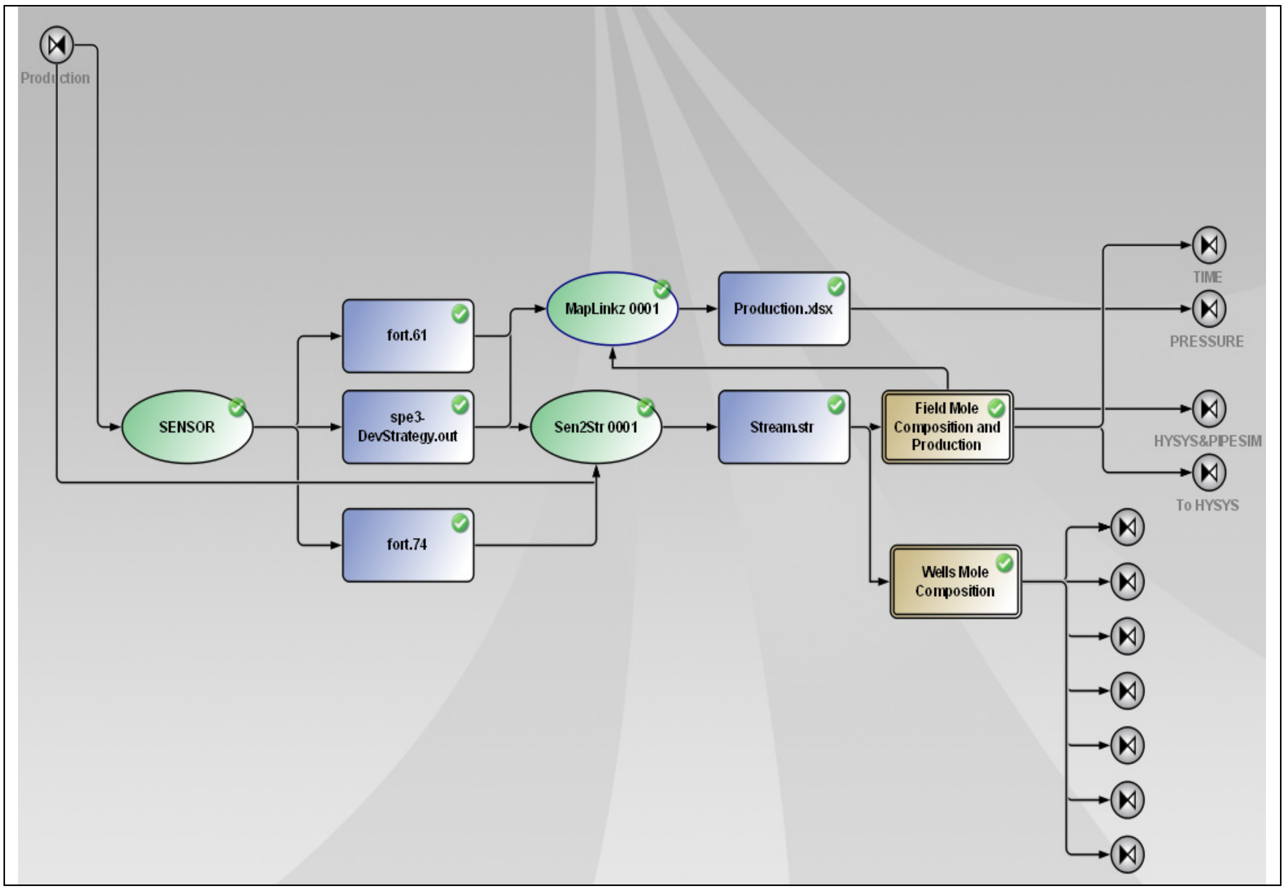


Figure 28 "Upstream integration"

Midstream

Midstream model has been studied in the Midstream part. Integration has been done using the VBA and VBS script. VBA script was used for the model initialization. The VBS script was used as process to run the model. Figure 29 “Midstream integration” is presenting midstream model integration process.

Initializing the model, VBA and VBS scripts are created the “variable” data file. Data file contains of default composition, tubing specification and boundary conditions. Composition, choke ID and boundary pressures has been linking to PIPE-IT optimizer as variable parameters for optimization purpose. Further VBS script was used as a process to read the “output.pns” file. In order to get feed for downstream application, output stream has been sorted by wells, pipeline and nodes.

NOTE!!! The Midstream link is not transferred the field /well composition. The production strategy has been defined manually!!!

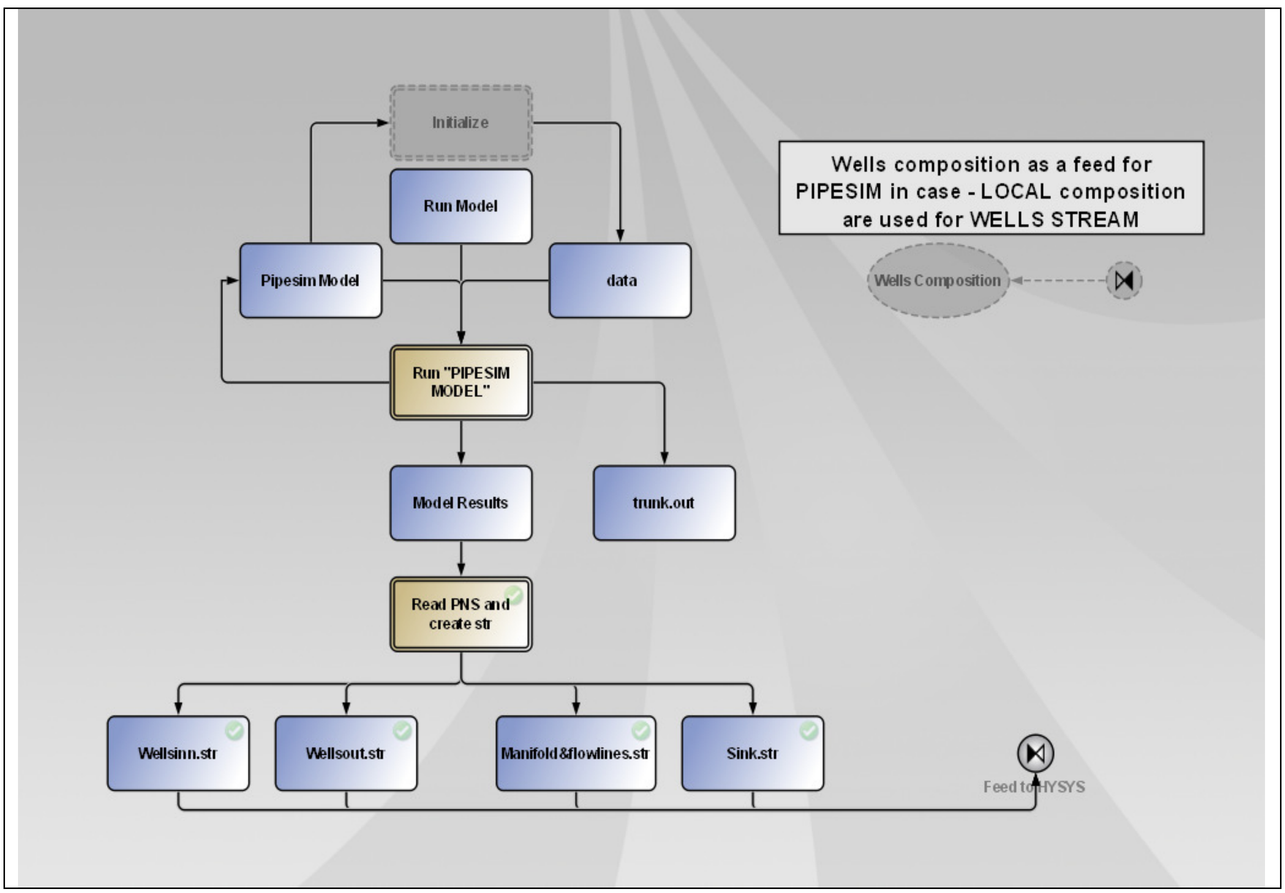


Figure 29 “Midstream integration”

Downstream

Downstream model has been studied in the "Downstream" part. Integration was done using the Ruby script as a process driver to run the model insight from PIPE-IT. Figure 30 "Downstream integration" is presenting the HYSYS integration process.

Average filed mole production stream, obtained from the "upstream", was used as a feed to run the model. The output products are composition molar flow of "Condensate", "Dry Gas", "Cycling Gas", "NGL" and "LNG". Specification of the downstream model is explained above in downstream "Model" part.

IAM characterized by one main composition stream from the reservoir to market. Figure 31 is presented the IAM composition stream. Wells molar compositions are fed to midstream model, which has been designed using PIPESIM. Midstream has been integrated in downstream model using UPSTREAM link. Thus, midstream and downstream was integrated in one model and mounted on PIPE-IT integration platform. PIPE-IT has used the PIPESIM's ENGINE and HYSYS's ENGINE to handle production and thyrmodynamical – process performances via Ruby script.

NOTE!!! Actually, "Cycling Gas" stream is not matched with stream that is used as injection fluid. That is because of the downstream model has been designed for gas-condensate production. The "Cycling Gas" stream represents the "virtual" volume of gas assigned for the cyclic gas injection. Also, the HYSYS model has been simplified, by using splitter to represent dehydration process.

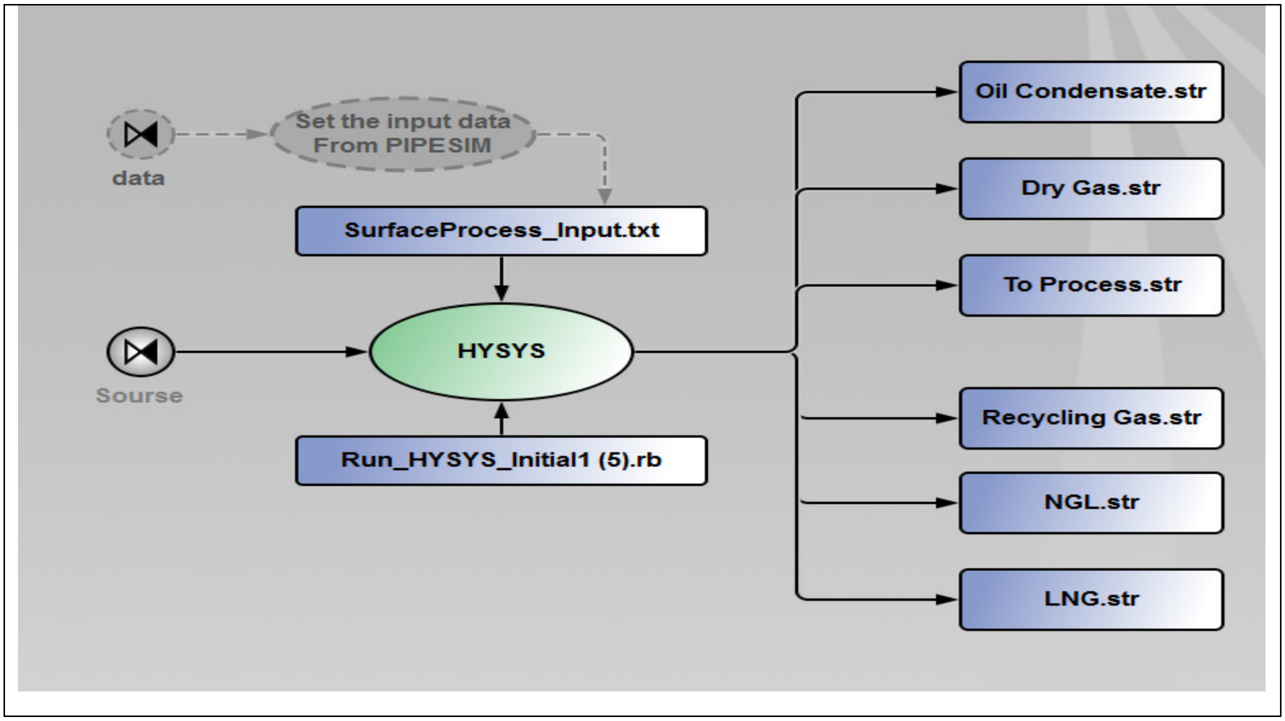


Figure 30 “Downstream integration”

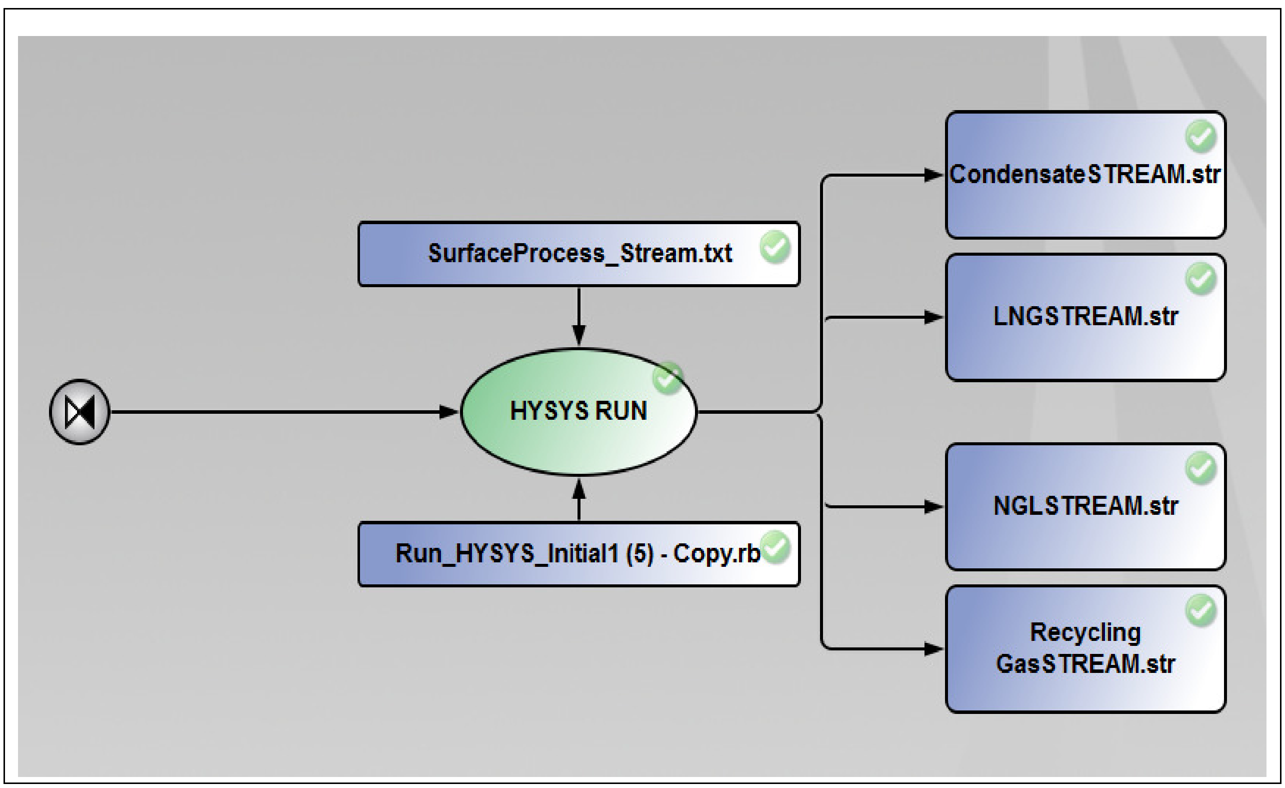


Figure 31 Midstream and Downstream integration

Optimization

In order to produce the gas-condensate field in 15 years with high efficiency the IAM has been developed. The result of upstream is a development strategy of the gas-condensate production. Midstream and downstream models gives a steady state solution. In order to obtain midstream production strategy and generate wellheads pressure, optimization has been done manually. Results are listed on Figure 18 “Production Strategy.”

Downstream model has been linked with upstream to improve gas-condensate development strategy. Result is a series of steady state solutions presented bellow. Downstream optimization has been described in downstream Optimization section.

Result

One of the important criteria of field development is assets composition flow. So, Figure 32-Figure 38 shows gas-condensate assets production, actually composition molar flow of the “Condensate”, “Dry Gas”, “Cycling Gas”, ”NGL” and “LNG”. Summarizing the outcome, different strategies has been applied for the gas-condensate production. The figures bellow shows integrated process efficiency and sweep efficiency of VGD and C/V gas drive mechanisms applied to enhance condensate production.

Planned FGPR =90 MMscf/d has been riched in 105 days. Plateau is taking place up to 4000days.Condensate mole production is depicted on Figure 32. Dehydration efficiency of the produced gas is shown on Figure 33 “Dry Gas Prodcution”. Composition of the dry gas is 76% of methane. Mole production and composition for NGL is presented on Figure 36” NGL Production”. LNG mole production and composition is listed on Figure 37 “LNG Production”. The assets standard actual volumetric flow is shown on Figure 38 “Std Actual Flow”.

During the depletion, production time from 0 -600 days, condensate production is rapidly decline for the all range of intermediate components. That is happening because of the most retrograde area are not swept in reservoir. Composition of produced gas is became leaner therefore the processed assets production decline.

During the cycling gas strategy, production time from 600 days – 2750 days, condensate production has been improved by the lean injection gas. Field condensate production slightly and continually decline. Vaporizing gas drive mechanism (VGD) is taking place. Condensate production of the intermediate components rapidly increased especially for C4-6. The mole production of the processed dry gas therefore NGL and LNG are increased. That is happening because of the well stream became richer due to VGD gas drive mechanism.

During cyclic gas strategy, production time from the 2750-4250 days, cyclic injection volume of lean gas has been increased up to 89% of total field produced. At this period four injectors are involved in gas injection process and cycling lean gas was reallocated. Decline condensate production was record due to drive mechanism has been changed from VGD on C/V therefore the sweep efficiency for condensate production was decline. Assets production rapidly decline due to 89% of the FGPR is injected back to enhance the condensate production.

Blowdown period, from the 4250 - 5480 days, reservoir is almost depleted, the C/V sweep efficiency is not reasonable therefore all produced gas is fed to the process. Field condensate production is rapidly decline. The FGPR is significantly raised during the blowdown. The assets mole production significantly increased and then rapidly falls. Increased mole production is happening because of significantly raised processing FGPR. When the sustainable volume of gas for C/V mechanism has been produced the mole production rapidly falls.

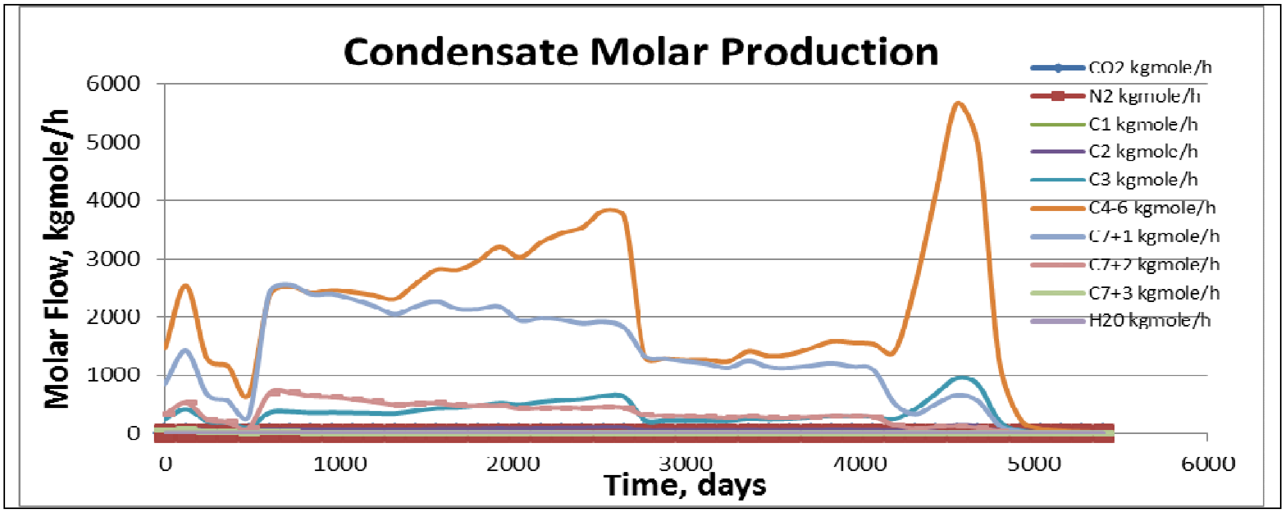


Figure 32 "Condensate Molar Production"

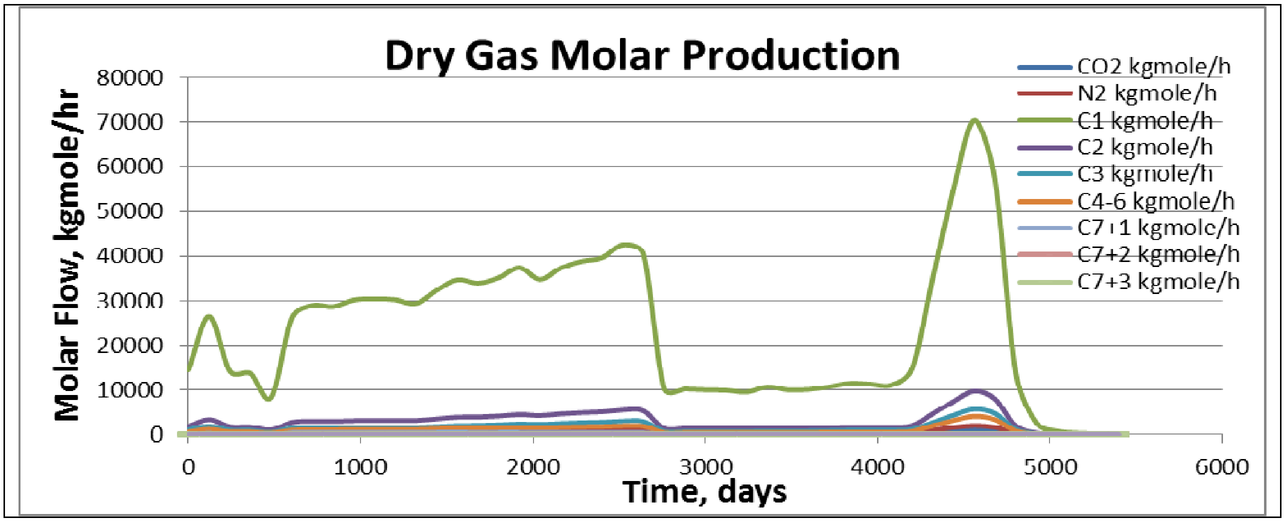


Figure 33 "Dry Gas Prodcution"

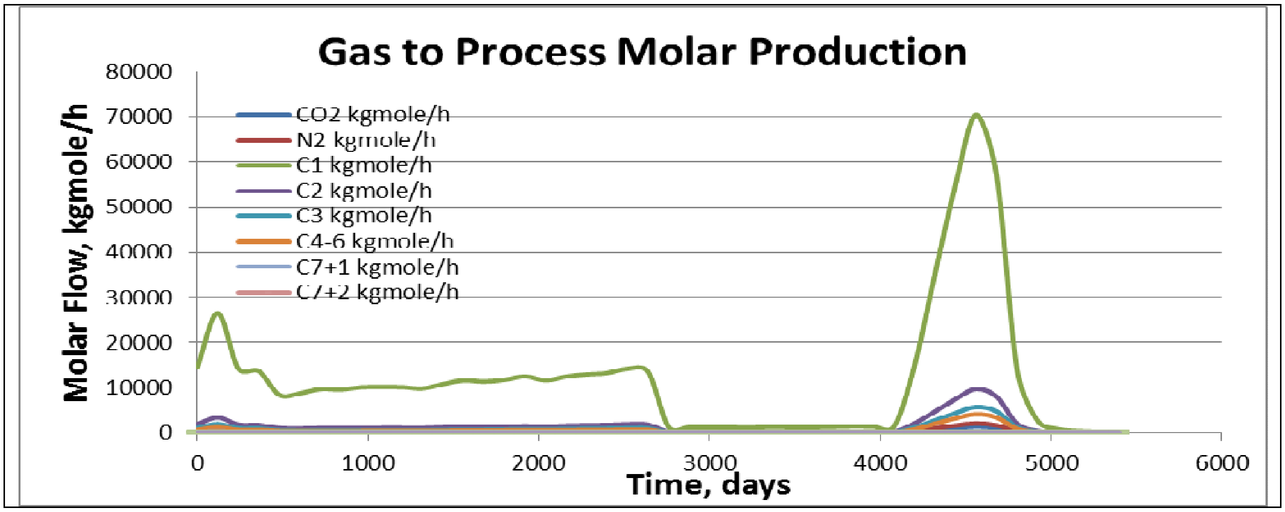


Figure 34 "Feed to NGL and LNG"

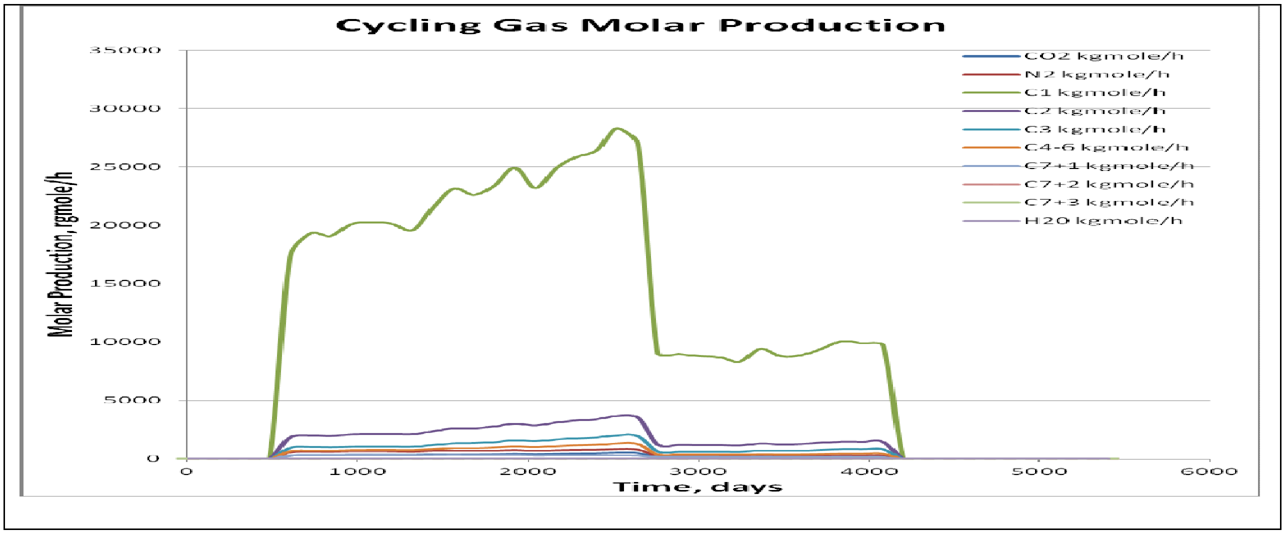


Figure 35 "Cycling Gas"

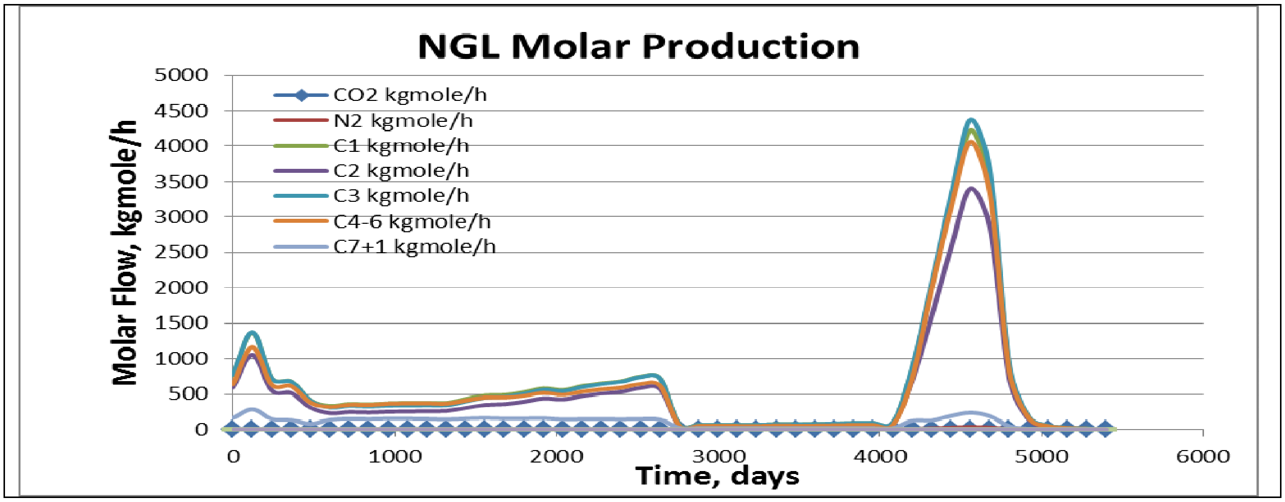


Figure 36" NGL Production"

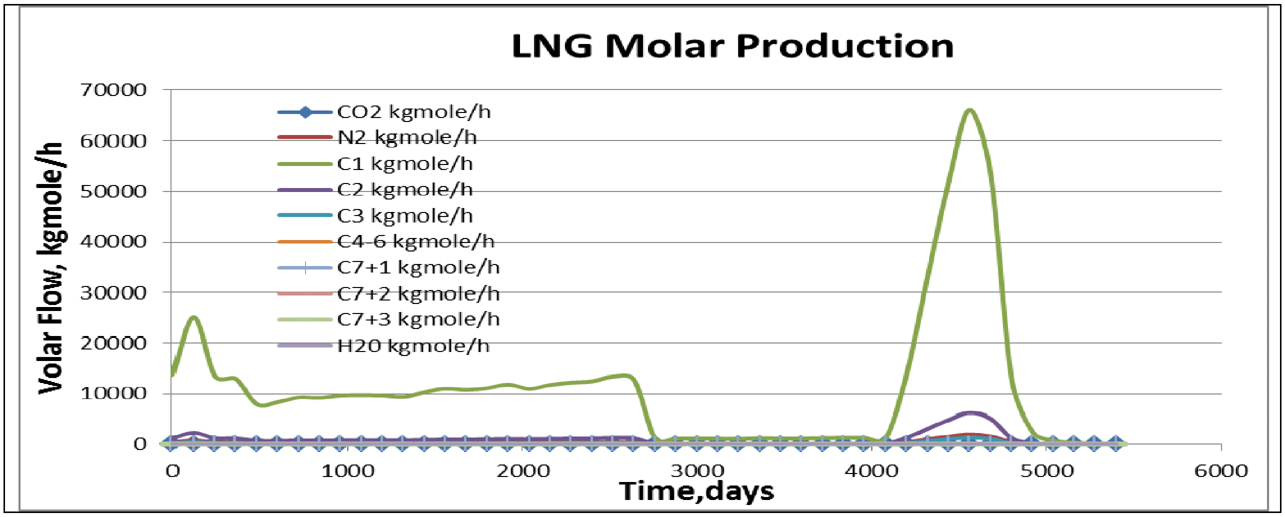


Figure 37 "LNG Production"

Result

Result of the IAM is main stream from the reservoir to the market of the gas-condensate assets. IAM has been developed using PIPE-IT platform. Integration of the upstream, midstream and downstream applications is a challenge to use the reservoir, production and process engineering skills. Upstream, midstream and downstream applications have been designed as simple models represented real case. In order to enhance gas-condensate production, different cases have been studied. Development strategy for the gas-condensate field has been defined based on real case "Sleipner Os Ty gas-condensate filed". To define "midstream" production strategy and to simulate the production problems such as liquid loading and flow insurance wells and pipelines performance have been simulated. Thermodynamic aspects such as three stage separation, dehydration (absorption -TEG), simplified CO2 extraction and simplified NGL and LNG Extraction processes were included in downstream steady state model.

The result of IAM is presented on Figure 38 "Std Actual Flow". The ultimate recovery has been riched 60% for the condensate and 84% for the produced gas.

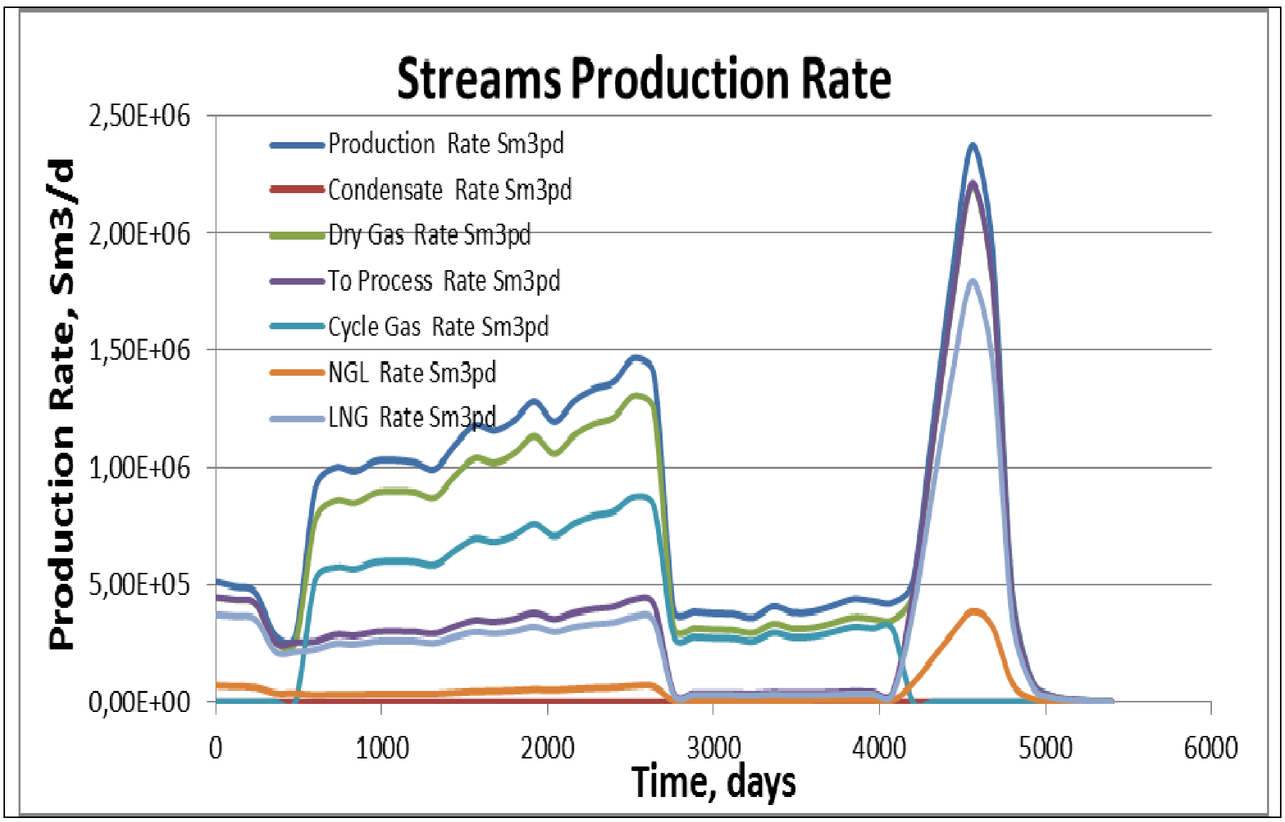


Figure 38 "Std Actual Flow"

Conclusions and Discussion

The fundamental understanding of the whole production chain of gas-condensate field has been demonstrated. Complexity of composition applications has been modeled and described for gas-condensate field development. VGD and C/V gas drive mechanism have been studied and applied in development strategy. The common problem such as liquid loading phenomena occurs during the gas production has been studied and modeled. Thermodynamic, steady state model has been designed in order to study separation, dehydration, CO2 extraction, NGL and LNG production processes. Long term production forecast has been obtained for gas-condensate field development. Assets prediction has been obtained based on the integration of the basic composition applications such as Upstream, Midstream and Downstream on IAM.

The main conclusions are:

1. The IAM has shown the valuable engineering aspects for the field development process.
2. The IAM shows whole production strategy chain, thus identifying the global constraints and optimizing it. IAM gives much accurate field assets prediction and long term forecasting.
3. The IAM gives a modeling flexibility to solve the global problems and save the valuable time for the decision making process.
4. The IAM gives an advantage in project NPV determination.
5. The standalone Upstream, downstream and Midstream simulators gives a modeling flexibility to solve local problems.

Recommendation

IAM has been designed and optimized based on integration of the Upstream, Midstream and Downstream standalone applications. The main aspects and specifications of those applications have been described in this thesis in correspondent chapters.

There are some recommendations to improve the IAM are:

1. Designing and integrating the “Gas Cycling” model improved by MMP and MME tests.
2. Designing and integrating the composition gas injection model
3. Programming the” VBA and VBS” scripts for the whole midstream integration.
4. Improving the process model, adding the absorption process of CO_2 extraction and “Cascade” LNG production.
5. NPV evaluation.

References

Arne Fredheim, Even Solbaa. (2012). *Natural Gas Technology.* Trondheim: NTNU.

Rahmawati S. et all. (2010). Multi-Field Assets Integrated Optimization Benchmark. *SPE 130768* .

Aspen Technology, i. (n.d.). HYSYS manual.

Coats Engineering, I. (n.d.). SENSOR Manual.

Curtis .H. Whitson. *PVT SPE Phase Behavior.*

CurtisH.Whitson,Michael Golan. *Well Performance.*

Eikeland M., Hansen H. (2009). Dry Gas Reinjection in a Strong Water Drive Gas-Condensate Reservoir "Sleipner Os Ty field". *SPE 110309* .

Gonzalez.F et all. (2010). A Fully Composition Integrated Asset Model for a Gas -Condensate Field. *SPE 134141* .

Herald W. Winkler/ Sidney S. Smith. *CAMCO Gas-lift Manual.*

Høier L, Whitson C. (2001). Miscibility Variation in Compositionally Grading Reservoirs. *SPE* .

Juell.A et al. (2009). Model-based Integration and Optimization - Gas Cycling Benchmark. *SPE 121252* .

Kenyon E., Alda G. (1987). Gas Cycling of Retrograde Reservoirs. *SPE 122278* .

Kenyon, D. E. (1987). Gas Cycling of Retrograde Condensate Reservoir. *SPE* .

Petrostreamz. (n.d.). PIPE-IT Manual.

Schlumberger. (2011). PIPESIM Manual.

Solomon F. et al. (2008). Critical Review of Existing Solutions to Predict and Model Liquid Loading in Gas Wells. *SPE 115933* .

T.Mishenko, I. *Well's Production* .

Zick.A. (1986). A Combined Condensing/Vaporizing Mechanism in the Displacement of oil by Enriched Gas. *SPE 15493* .

Appendix A "Upstream"

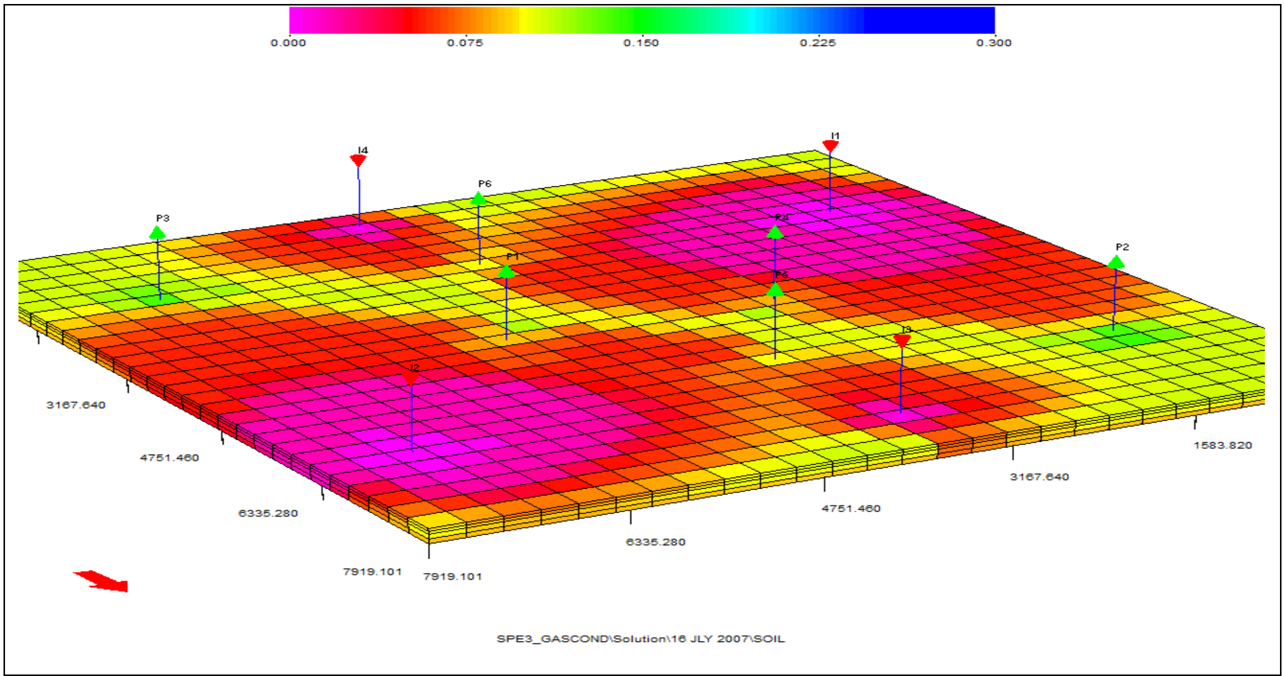


Figure 39 "Gas-condensate field"

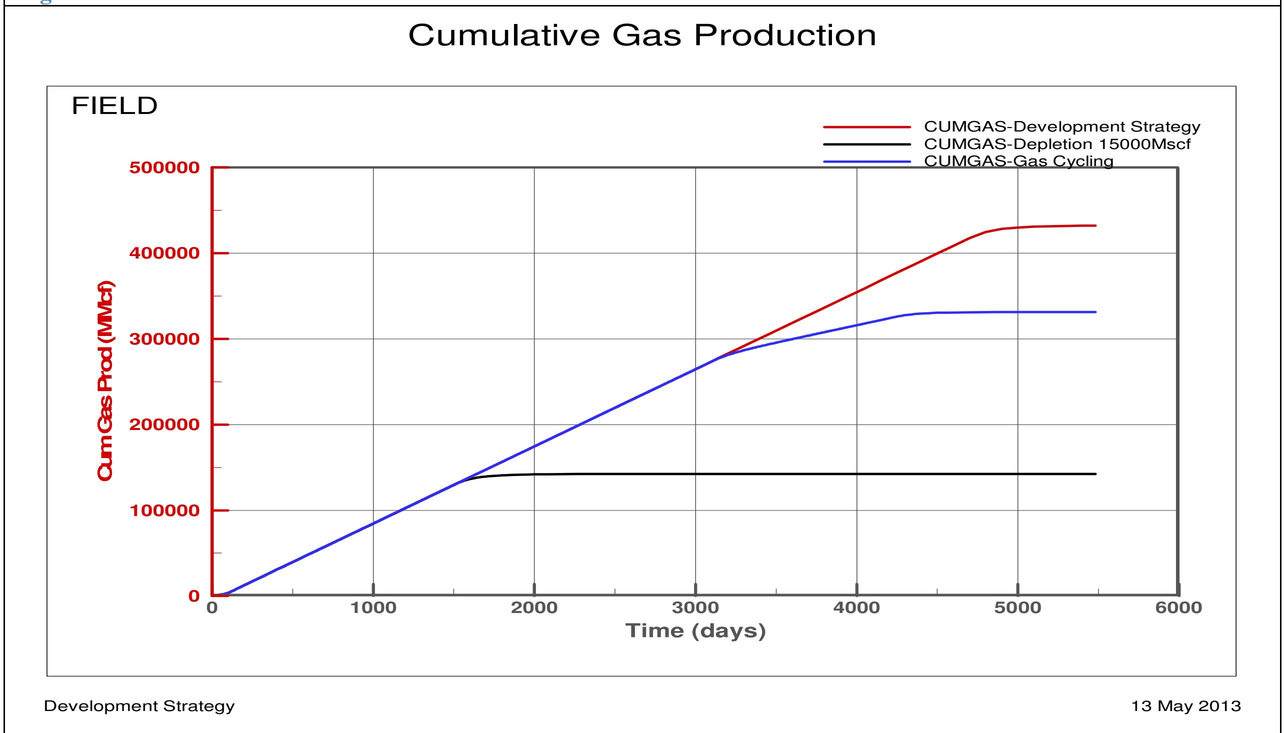


Figure 40 " Total gas production"

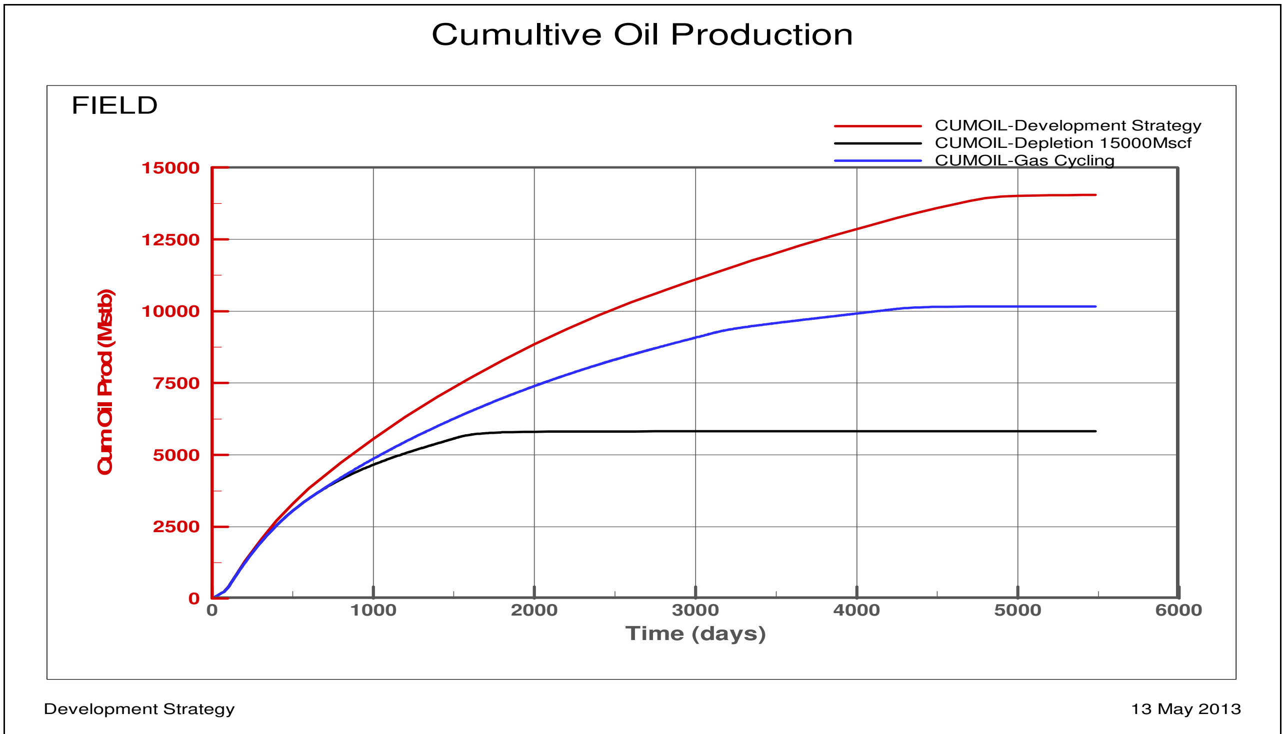


Figure 41 "Total condensate production"

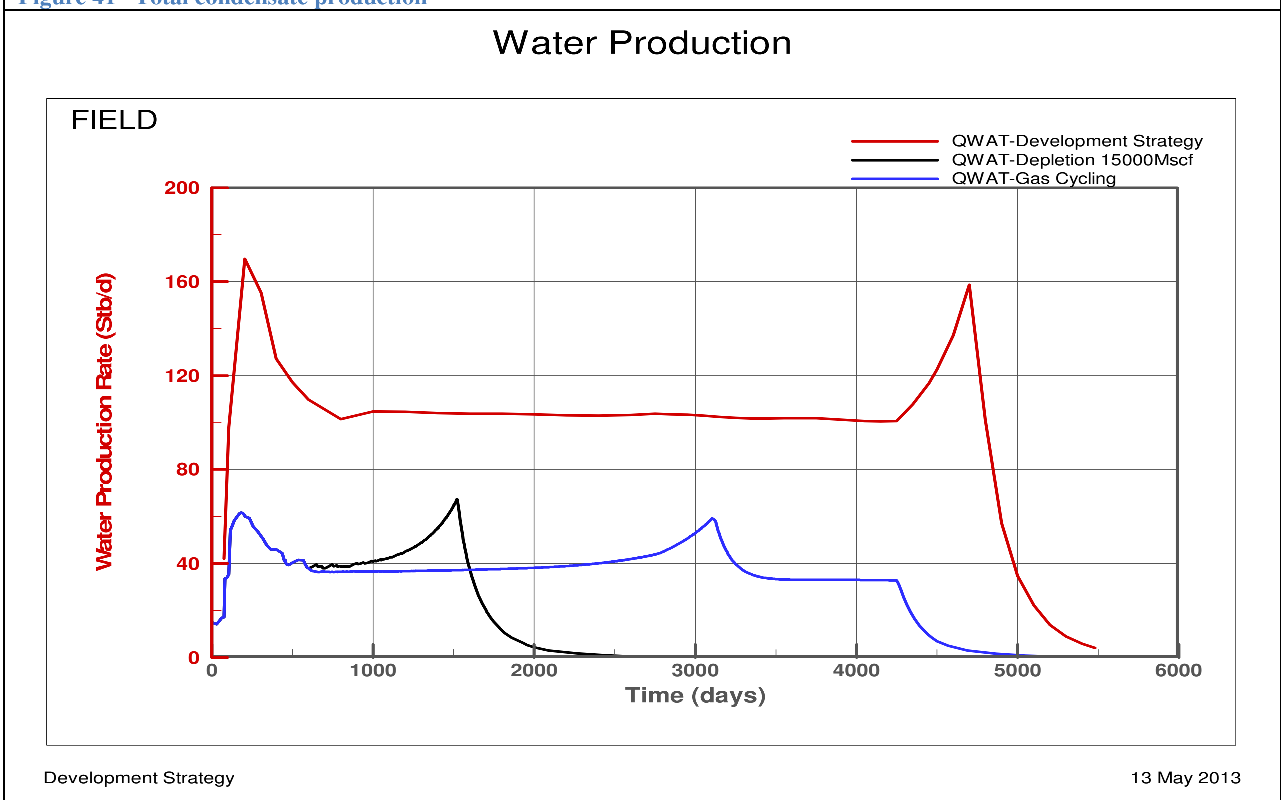


Figure 42 "Water Production"

Appendix B "Midstream"

Branch Name		ProdWel6	ProdWell1	ProdWell2	ProdWell3	ProdWell4	ProdWell5	flowline	flowline1	flowline2	flowline3	flowline4	flowline6	Mainfold
6														
Branch No		2	3	4	5	6	7	8	9	10	11	12	13	1
Branch Type		Source	Source	Source	Source	Source	Source	Link	Link	Link	Link	Link	Link	Sink
Boundary condition		Pressure	Pressure	Pressure	Pressure	Pressure	Pressure							Pressure
Flowing from		ProdWel6	ProdWell1	ProdWell2	ProdWell3	ProdWell4	ProdWell5	WH 5	WH 1	WH 2	WH 3	WH 4	WH 6	J_4
to		WH 6	WH 1	WH 2	WH 3	WH 4	WH 5	J_4	J_4	J_4	J_4	J_4	J_4	Sink_2
Flow direction		Forward	Forward	Forward	Forward	Forward	Forward	Reverse	Reverse	Forward	Forward	Forward	Forward	Forward
Inlet														
Temperature	F	200	200	200	200	200	200	149.29	148.70	148.71	149.18	149.32	149.18	146.66
Pressure	psia	3550	3550	3550	3550	3550	3550	993.14	971.92	971.87	988.30	993.15	988.30	945.80
Enthalpy	Btu/lb	-78.43	-78.43	-78.43	-78.43	-78.43	-78.43	-87.01	-87.00	-86.99	-86.99	-86.99	-86.99	-87.68
Mass Flowrate	lb/sec	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	85.87
Stock-tank Liquid	sbbl/day	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	10898.14
Stock-tank Oil	sbbl/day	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	10898.14
Stock-tank Gas	mmscfd	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	68.59
Flowing Liquid	bbl/day	3340.85	3340.85	3340.85	3340.85	3340.85	3340.85	2355.31	2346.68	2346.63	2353.34	2355.26	2353.34	14023.82
Flowing Oil	bbl/day	3340.85	3340.85	3340.85	3340.85	3340.85	3340.85	2355.31	2346.68	2346.63	2353.34	2355.26	2353.34	14023.82
Flowing Gas	mmscfd	8.37	8.37	8.37	8.37	8.37	8.37	10.46	10.47	10.47	10.46	10.46	10.46	62.95
Flowing Gas	cf/min	27.22	27.22	27.22	27.22	27.22	27.22	112.12	114.83	114.84	112.74	112.13	112.74	707.40
Outlet														
Temperature	F	149.18	148.70	148.71	149.18	149.32	149.29	146.21	147.14	147.16	146.61	146.24	146.61	141.52
Pressure	psia	988.30	971.29	971.87	988.30	993.15	992.10	950.16	950.16	950.10	952.41	950.16	952.41	805.00
Enthalpy	Btu/lb	-86.99	-86.99	-86.99	-86.99	-86.99	-86.99	-87.98	-87.49	-87.48	-87.81	-87.97	-87.81	-88.10
Mass Flowrate	lb/sec	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	85.87
Stock-tank Liquid	sbbl/day	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	10898.14
Stock-tank Oil	sbbl/day	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	1816.36	10898.14
Stock-tank Gas	mmscfd	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	11.43	68.59
Flowing Liquid	bbl/day	2353.34	2346.39	2346.63	2353.34	2355.26	2354.85	2340.10	2338.72	2338.67	2340.60	2340.06	2340.60	13668.68
Flowing Oil	bbl/day	2353.34	2346.39	2346.63	2353.34	2355.26	2354.85	2340.10	2338.72	2338.67	2340.60	2340.06	2340.60	13668.68
Flowing Gas	mmscfd	10.46	10.48	10.47	10.46	10.46	10.46	10.48	10.49	10.49	10.48	10.48	10.48	63.67
Flowing Gas	cf/min	112.74	114.92	114.84	112.74	112.13	112.26	117.11	117.42	117.43	116.91	117.12	116.91	842.63
Mass Loss	lb/sec	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Loss	Btu/hr	440863	440863	440863	440863	440863	440863	50435	25250.7	25255	42095	50451	42095	129647
State		Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
Frictional Drop	psia	1605.73	1622.75	1622.16	1605.73	1600.9	1601.93	-42.99	-21.7656	21.768	35.889	42.991	35.889	140.797
including choke	psia	1603.81	1620.82	1620.24	1603.81	1599	1600.01	0	0	0	0	0	0	0
Elevational Drop	psia	951.088	951.088	951.088	951.088	951.09	951.088	0	0	0	0	0	0	0
Static Drop	psia	4.87834	4.87834	4.87834	4.87834	4.8783	4.87834	0	0	0	0	0	0	0
Outlet Compositio	mol%													
Carbon Dioxide		1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.210
Nitrogen		1.948	1.948	1.948	1.948	1.948	1.948	1.948	1.948	1.948	1.948	1.948	1.948	1.948
Methane		66.160	66.160	66.160	66.160	66.160	66.160	66.160	66.160	66.160	66.160	66.160	66.160	66.160
Ethane		8.679	8.679	8.679	8.679	8.679	8.679	8.679	8.679	8.679	8.679	8.679	8.679	8.679
Propane		5.888	5.888	5.888	5.888	5.888	5.888	5.888	5.888	5.888	5.888	5.888	5.888	5.888
C4-6		9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610
C7+1		4.635	4.635	4.635	4.635	4.635	4.635	4.635	4.635	4.635	4.635	4.635	4.635	4.635
C7+2		1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
C7+3		0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302
Water		0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
Composition Man:	Handle	72EBFD9,	72EBFD9	72EBFD9	72EBFD9	72EBFD9	72EBFD9,	72EBFD:	72EBFD9/	72EBFD:	72EBFD:	72EBFD:	72EBFD:	72EBFD9/

Table 10 Pipesim Output file

Appendix C "Downstream"

Process			Separation				Dehydration						Ex-n"CO2"	Extraction	
Stream		mix.stream	Gas1	Gas2	Gas3	Condensate	Gas"H2O"	Dry Gas	RichTEG	Sour Gas	cycling	process	Ext"CO2"	NGL	LNG
Mole Frac	CO2	1.26E-02	1.36E-02	1.85E-02	1.42E-02	3.72E-04	1.42E-02	1.42E-02	3.26E-03	8.68E-03	1.42E-02	1.42E-02	1.44E-07	1.38E-07	1.45E-07
Mole Frac	N2	1.96E-02	2.40E-02	7.63E-03	6.60E-04	1.32E-06	2.21E-02	2.21E-02	1.91E-03	5.08E-03	2.21E-02	2.21E-02	2.24E-02	2.05E-03	2.62E-02
Mole Frac	C1	0.68103176	0.794078	0.5747898	1.66E-01	1.27E-03	7.66E-01	0.766205	7.72E-03	2.06E-02	7.66E-01	7.66E-01	0.7772213	2.57E-01	0.872931
Mole Frac	C2	9.01E-02	8.79E-02	1.81E-01	2.47E-01	1.49E-02	9.95E-02	9.95E-02	2.36E-03	6.29E-03	9.95E-02	9.95E-02	0.1009707	2.02E-01	8.23E-02
Mole Frac	C3	5.87E-02	4.24E-02	0.1300616	3.26E-01	9.19E-02	5.46E-02	5.46E-02	1.71E-03	4.55E-03	5.46E-02	5.46E-02	5.54E-02	0.258517	1.80E-02
Mole Frac	C4-6	9.25E-02	3.00E-02	7.39E-02	2.10E-01	5.51E-01	3.52E-02	3.52E-02	3.30E-04	8.79E-04	3.52E-02	3.52E-02	3.57E-02	0.226621	5.87E-04
Mole Frac	C7+1	3.77E-02	7.52E-03	1.31E-02	3.46E-02	2.76E-01	8.00E-03	8.01E-03	2.95E-05	7.86E-05	8.01E-03	8.01E-03	8.12E-03	5.21E-02	2.13E-05
Mole Frac	C7+2	7.22E-03	5.55E-05	1.26E-05	2.14E-05	6.46E-02	4.95E-05	4.95E-05	3.22E-09	8.57E-09	4.95E-05	4.95E-05	5.02E-05	3.23E-04	3.25E-12
Mole Frac	C7+3	9.44E-06	2.82E-10	2.06E-12	1.67E-12	8.50E-05	2.51E-10	2.51E-10	2.16E-17	5.75E-17	2.51E-10	2.51E-10	2.55E-10	1.64E-09	5.45E-25
Mole Frac	H20	3.62E-04	3.89E-04	5.46E-04	4.10E-04	1.02E-05	4.06E-04	9.29E-05	4.78E-01	0.951975	9.29E-05	9.29E-05	9.43E-05	5.90E-04	2.93E-06
Mole Frac	TEG	0.00E+00	0	0	0	0	0	1.24E-07	0.504761	1.90E-03	1.24E-07	1.24E-07	1.26E-07	8.11E-07	1.69E-16

Table 11 "SS Stream Composition"

T1	T2	CO2	N2	C1	C2	C3	C4-6	C7+1	C7+2	C7+3	H20	Recovery Mechanism
d	d	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	
0	120	1.0323	0.0045	3.6496	37.7253	237.846	1458.14	852.798	323.946	65.2796	1.1E-05	Depletion, 6 producers 15000Mscf/d
120	240	1.7582	0.0075	6.2442	65.5358	413.155	2536.88	1412.52	523.364	70.531	1.1E-05	
240	360	0.8667	0.0036	3.0832	32.8941	207.76	1284.08	670.203	239.007	20.4822	9.9E-06	
360	480	0.7565	0.0031	2.6875	29.1861	184.925	1155.95	556.207	187.959	9.90452	9.1E-06	
480	600	0.4195	0.0016	1.485	16.4173	104.413	661.437	290.971	92.013	3.14673	8.3E-06	
600	720	2.0202	0.0118	8.5872	65.5594	352.668	2366.02	2421.11	687.544	13.1357	1.4E-05	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mscf/d, FIGR=60000Mscf/d, Retrograde Condensate Vaporized by Multi Contact Misciable Gas Cycling
720	840	2.1282	0.0124	9.0649	69.0267	369.611	2513.2	2547.35	696.905	9.76655	1.3E-05	
840	960	2.0133	0.0116	8.5457	65.5089	350.726	2404.64	2388.6	635.666	7.54587	1.3E-05	
960	1080	2.0359	0.0116	8.6024	66.4961	356.025	2457.59	2391.72	620.213	6.26694	1.2E-05	
1080	1200	1.9845	0.0111	8.3171	65.2339	349.598	2420.3	2300.86	581.332	5.14127	1.2E-05	
1200	1320	1.9229	0.0104	7.9438	63.9572	344.13	2370.75	2187.31	538.127	4.24624	1.1E-05	
1320	1440	1.8449	0.0095	7.474	62.4363	338.935	2304.2	2046.53	490.343	3.46804	1.1E-05	
1440	1560	2.0228	0.01	8.017	69.8814	384.468	2566.19	2177.33	508.469	3.21204	1.1E-05	
1560	1680	2.175	0.0102	8.4316	76.7982	429.362	2809.94	2262.25	515.275	2.82742	1.1E-05	
1680	1800	2.1297	0.0096	8.0886	76.7604	436.065	2803.39	2136.26	475.971	2.19697	1.1E-05	
1800	1920	2.2087	0.0095	8.2283	81.1637	468.122	2962.45	2131.28	466.861	1.77189	1.0E-05	
1920	2040	2.3483	0.0097	8.5969	87.7978	513.288	3205.92	2177.9	473.042	1.45925	1.0E-05	
2040	2160	2.1763	0.0087	7.8383	82.6775	489.476	3023.17	1935.51	420.842	1.09119	1.0E-05	
2160	2280	2.3208	0.009	8.2358	89.4449	535.686	3278.29	1976.8	434.506	0.95528	1.0E-05	
2280	2400	2.3941	0.009	8.3815	93.5055	566.155	3438.02	1949.89	436.429	0.81095	9.9E-06	
2400	2520	2.424	0.0088	8.3813	95.8524	586.439	3537.89	1885.25	431.494	0.67568	9.7E-06	
2520	2640	2.5783	0.0092	8.813	103.159	637.5	3824.06	1911.97	448.116	0.58848	9.6E-06	
2640	2760	2.4922	0.0087	8.4598	100.304	622.619	3710.48	1810.84	432.496	0.48011	9.7E-06	
2760	2880	1.1884	0.0052	4.4273	41.8811	223.71	1323.83	1328.72	305.791	0.30525	1.8E-05	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mscf/d, FIGR=80000Mscf/d, Retrograde Condensate Vaporized by first Contact Misciable Gas Cycling
2880	3000	1.1472	0.0051	4.2994	40.2827	214.975	1285.47	1282.17	299.209	0.28208	1.7E-05	
3000	3120	1.1151	0.0049	4.1572	39.5319	213.492	1265.37	1231.93	290.433	0.26563	1.7E-05	
3120	3240	1.0987	0.0047	4.0575	39.4622	216.346	1266.22	1192.81	282.194	0.25855	1.7E-05	
3240	3360	1.0509	0.0044	3.836	38.2742	212.385	1226.88	1120.07	264.069	0.24859	1.7E-05	
3360	3480	1.1861	0.0048	4.2747	43.874	246.434	1401.78	1240.03	290.723	0.28176	1.7E-05	
3480	3600	1.1071	0.0044	3.9419	41.5823	236.786	1325.37	1133.98	266.009	0.25912	1.7E-05	
3600	3720	1.1175	0.0044	3.9392	42.5355	245.679	1356.41	1120.58	265.759	0.25334	1.6E-05	
3720	3840	1.1843	0.0046	4.1383	45.6038	267.233	1459.52	1159.96	280.527	0.26077	1.6E-05	
3840	3960	1.2567	0.0048	4.3606	48.8499	289.953	1572.49	1202.07	297.299	0.27107	1.6E-05	
3960	4080	1.2214	0.0046	4.2126	47.8663	287.398	1551.76	1140.54	288.344	0.26109	1.6E-05	
4080	4200	1.1886	0.0044	4.0784	46.9031	284.368	1531.57	1084.84	279.186	0.25366	1.6E-05	
4200	4320	0.8788	0.0028	2.8783	37.2216	243.521	1405.62	509.582	138.503	0.12319	9.2E-06	
4320	4440	1.3504	0.0037	4.2372	61.3384	416.344	2555.35	328.864	78.0272	0.04183	6.2E-06	Blowdown, Natural flow, Produced gas - on Marcet
4440	4560	2.1919	0.0059	6.8291	100.497	683.905	4158.51	504.105	107.187	0.03927	6.4E-06	
4560	4680	2.9914	0.0078	9.2436	138.471	945.766	5674.61	655.241	122.272	0.02845	6.8E-06	
4680	4800	2.6035	0.0067	7.9936	121.462	833.218	4934.09	551.207	93.1117	0.01453	7.2E-06	
4800	4920	0.6733	0.0017	2.0592	31.55	217.14	1274.15	140.412	22.3969	0.00287	7.6E-06	
4920	5040	0.1325	0.0003	0.406	6.23096	42.9975	251.287	27.765	4.30555	0.00051	7.8E-06	
5040	5160	0.0408	0.0001	0.1245	1.91738	13.2184	77.006	8.53292	1.29978	0.00015	7.9E-06	
5160	5280	0.0182	5E-05	0.0553	0.854144	5.88796	34.2501	3.79455	0.57345	6.4E-05	8.0E-06	
5280	5400	0.0091	2E-05	0.0277	0.426688	2.94412	17.1133	1.8967	0.285162	3.1E-05	8.0E-06	
5400	5480	0.0043	1E-05	0.0131	0.201478	1.39096	8.08064	0.89558	0.134253	1.5E-05	8.1E-06	

Table 12 "Condensate stream"

T1	T2	CO2	N2	C1	C2	C3	C4-6	C7+1	C7+2	C7+3	H20	Recovery
d	d	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	
0	120	263.79	426.47	14477	1861.1	1050	643.42	159.26	1.3458	0.00085	0	Depletion, 6 producers 15000Mscf/d
120	240	478.83	785.87	26503	3359.2	1885.9	1178.7	283.22	2.4406	0.00108	0	
240	360	254.94	424.87	14226	1777.3	993.02	636.48	146.2	1.268	0.00037	0	
360	480	243.38	411.32	13679	1685.5	937.56	619.29	133.69	1.1477	0.00022	0	
480	600	147.66	252.39	8345.4	1016.7	563.56	383.96	77.099	0.644	8.16E-05	0	
600	720	429.51	831.26	26077	2748	1419.2	972.21	413.54	2.4176	0.00014	0	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mscf/d, FIGR=60000Mscf/d. Retrograde Condensate Vaporized by Multi Contact Miscible Gas Cycling
720	840	473.83	928.78	28953	3005.7	1536.1	1072.4	455.62	2.618	0.00011	0	
840	960	468.15	920.55	28661	2956.8	1501.3	1061.4	445.18	2.5347	8.98E-05	0	
960	1080	492.62	968.83	30173	3101.6	1565.8	1118.9	462.8	2.6108	7.95E-05	0	
1080	1200	498.38	973.86	30441	3136	1575.5	1133.1	460.7	2.5737	6.94E-05	0	
1200	1320	498.91	959.02	30228	3152.6	1580.6	1134.5	450.36	2.491	6.09E-05	0	
1320	1440	490.94	921.46	29377	3131	1574.3	1117.7	429.51	2.3528	5.26E-05	0	
1440	1560	547.97	1001.5	32321	3537.9	1792.9	1252.3	462.1	2.5085	5.13E-05	0	
1560	1680	597.12	1062.9	34714	3906.9	2001.5	1373.8	483.53	2.6032	4.74E-05	0	
1680	1800	591.2	1027.5	33922	3916.4	2029.3	1371.7	459.33	2.4579	3.85E-05	0	
1800	1920	619.91	1053.8	35142	4153.9	2175.8	1451.8	461.34	2.4653	3.25E-05	0	
1920	2040	666.81	1111.7	37401	4513.1	2386.4	1576.2	475.31	2.5553	2.80E-05	0	
2040	2160	626.26	1026	34793	4277.1	2280.9	1494.5	426.82	2.3295	2.19E-05	0	
2160	2280	677.44	1093.1	37325	4663.8	2506.2	1632.1	441.12	2.4659	2.00E-05	0	
2280	2400	709.38	1129.8	38801	4918.9	2662.1	1725.9	440.81	2.5409	1.77E-05	0	
2400	2520	729.11	1148.2	39627	5088.8	2772.8	1792.1	432.01	2.5773	1.54E-05	0	
2520	2640	786.86	1227.1	42525	5525.2	3030.8	1954.7	444.15	2.7453	1.39E-05	0	
2640	2760	752.77	1162.4	40462	5312.7	2927.5	1875.5	416.03	2.6241	1.13E-05	0	
2760	2880	195.58	284.1	10264	1365.8	721.48	427.88	174.41	0.7922	2.55E-06	0	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mscf/d, FIGR=80000Mscf/d. Retrograde Condensate Vaporized by first Contact Miscible Gas Cycling
2880	3000	192.84	284.96	10205	1339	704.46	422.98	171.84	0.7972	2.42E-06	0	
3000	3120	189.56	280.05	10019	1324.3	702.53	418.11	166.17	0.785	2.33E-06	0	
3120	3240	188.39	276.29	9911	1327.6	712.25	418.51	161.37	0.7723	2.32E-06	0	
3240	3360	181.75	263.59	9498.8	1292.7	699.26	405.6	152.03	0.7326	2.29E-06	0	
3360	3480	206.79	296.24	10727	1486.5	810.77	463.18	168.74	0.8174	2.67E-06	0	
3480	3600	194.26	275.26	10006	1411.4	777.6	437.18	154.5	0.7562	2.52E-06	0	
3600	3720	197.18	277.17	10102	1446	805.42	446.62	152.78	0.7624	2.52E-06	0	
3720	3840	210.39	294.12	10735	1555	875.77	480.46	158.52	0.8133	2.65E-06	0	
3840	3960	225.31	314.07	11468	1674.7	952.06	518.93	165.15	0.874	2.81E-06	0	
3960	4080	221.59	308.56	11264	1653.8	947.58	514.77	158.04	0.863	2.78E-06	0	
4080	4200	218.52	304.36	11101	1635.5	942.84	511.66	151.93	0.8529	2.78E-06	0	
4200	4320	279.35	424.65	14829	2026.2	1163.3	734.12	123.28	0.9281	3.42E-06	0	
4320	4440	655.03	1021	35235	4700.4	2732.5	2007	128.38	0.9969	2.62E-06	0	Blowdown, Natural flow, Produced gas – on Marcet
4440	4560	1029.5	1592.6	55062	7435.6	4347.6	3171.9	191.41	1.3445	2.44E-06	0	
4560	4680	1328.6	2028.1	70490	9674.2	5703	4107.7	236.12	1.4634	1.71E-06	0	
4680	4800	1083.6	1633.9	57071	7956.5	4733.8	3359.2	186.55	1.0469	8.30E-07	0	
4800	4920	266.03	397.01	13936	1964.7	1177.3	825.71	45.149	0.2388	1.56E-07	0	
4920	5040	51.053	76.918	2677.2	378.9	228.07	159.04	8.7083	0.0447	2.70E-08	0	
5040	5160	15.467	22.749	806.12	114.67	69.049	47.947	2.631	0.0133	7.64E-09	0	
5160	5280	6.8333	9.9822	355.32	50.66	30.522	21.151	1.16	0.0058	3.29E-09	0	
5280	5400	3.3926	4.9884	176.64	25.192	15.198	10.52	0.577	0.0029	1.61E-09	0	
5400	5480	1.5955	2.3572	83.162	11.862	7.1618	4.9538	0.2717	0.0013	7.53E-10	0	

Table 13 “Dry Gas stream”

T1	T2	CO2	N2	C1	C2	C3	C4-6	C7+1	C7+2	C7+3	H20	Recover
d	d	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	y
0	120	263.79	426.47	14477	1861.1	1050	643.41	159.26	1.3458	0.000852	0	Depletion, 6 producers 15000Mscf/d
120	240	478.83	785.87	26503	3359.2	1885.9	1178.7	283.22	2.4406	0.00108	0	
240	360	254.94	424.87	14226	1777.3	993.02	636.48	146.2	1.268	0.000372	0	
360	480	243.38	411.32	13679	1685.5	937.56	619.29	133.69	1.1477	2.16E-04	0	
480	600	147.66	252.39	8345.4	1016.7	563.56	383.96	77.099	0.644	8.16E-05	0	
600	720	143.03	276.81	8683.6	915.08	472.58	323.75	137.71	0.8051	4.51E-05	0	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mcsf/d. FIGR=60000Mscf/d. Retrograde Condensate Vaporized by Multi Contact Misciable Gas Cycling
720	840	157.79	309.28	9641.5	1000.9	511.51	357.12	151.72	0.8718	3.61E-05	0	
840	960	155.9	306.54	9544.2	984.61	499.92	353.45	148.24	0.844	2.99E-05	0	
960	1080	164.04	322.62	10048	1032.8	521.4	372.58	154.11	0.8694	2.65E-05	0	
1080	1200	165.96	324.3	10137	1044.3	524.64	377.31	153.41	0.857	2.31E-05	0	
1200	1320	166.14	319.35	10066	1049.8	526.35	377.79	149.97	0.8295	2.03E-05	0	
1320	1440	163.48	306.85	9782.6	1042.6	524.24	372.2	143.03	0.7835	1.75E-05	0	
1440	1560	182.47	333.5	10763	1178.1	597.03	417.02	153.88	0.8353	1.71E-05	0	
1560	1680	198.84	353.95	11560	1301	666.51	457.48	161.02	0.8669	1.58E-05	0	
1680	1800	196.87	342.16	11296	1304.2	675.76	456.79	152.96	0.8185	1.28E-05	0	
1800	1920	206.43	350.92	11702	1383.2	724.54	483.46	153.63	0.8209	1.08E-05	0	
1920	2040	222.05	370.18	12455	1502.9	794.69	524.88	158.28	0.8509	9.32E-06	0	
2040	2160	208.54	341.64	11586	1424.3	759.55	497.65	142.13	0.7757	7.28E-06	0	
2160	2280	225.59	364.02	12429	1553	834.55	543.49	146.89	0.8212	6.65E-06	0	
2280	2400	236.22	376.23	12921	1638	886.47	574.74	146.79	0.8461	5.89E-06	0	
2400	2520	242.79	382.36	13196	1694.6	923.35	596.76	143.86	0.8582	5.11E-06	0	
2520	2640	262.02	408.61	14161	1839.9	1009.3	650.91	147.9	0.9142	4.64E-06	0	
2640	2760	250.67	387.07	13474	1769.1	974.85	624.52	138.54	0.8738	3.77E-06	0	
2760	2880	23.47	34.093	1231.7	163.9	86.577	51.345	20.93	0.0951	3.06E-07	0	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mcsf/d. FIGR=80000Mscf/d. Retrograde Condensate Vaporized by first Contact Misciable Gas Cycling
2880	3000	23.141	34.195	1224.6	160.69	84.535	50.758	20.621	0.0957	2.90E-07	0	
3000	3120	22.747	33.606	1202.3	158.92	84.304	50.173	19.941	0.0942	2.79E-07	0	
3120	3240	22.606	33.154	1189.3	159.32	85.47	50.222	19.365	0.0927	2.78E-07	0	
3240	3360	21.81	31.631	1139.9	155.13	83.911	48.672	18.243	0.0879	2.75E-07	0	
3360	3480	24.815	35.548	1287.2	178.37	97.293	55.581	20.249	0.0981	3.21E-07	0	
3480	3600	23.311	33.032	1200.8	169.36	93.312	52.461	18.539	0.0907	3.02E-07	0	
3600	3720	23.661	33.26	1212.2	173.52	96.651	53.595	18.333	0.0915	3.02E-07	0	
3720	3840	25.247	35.294	1288.2	186.6	105.09	57.655	19.022	0.0976	3.17E-07	0	
3840	3960	27.037	37.688	1376.2	200.96	114.25	62.272	19.818	0.1049	3.38E-07	0	
3960	4080	26.591	37.028	1351.6	198.46	113.71	61.772	18.965	0.1036	3.34E-07	0	
4080	4200	26.222	36.523	1332.2	196.26	113.14	61.399	18.231	0.1023	3.34E-07	0	
4200	4320	279.35	424.65	14829	2026.2	1163.3	734.12	123.28	0.9281	3.42E-06	0	
4320	4440	655.03	1021	35235	4700.4	2732.5	2007	128.38	0.9969	2.62E-06	0	Blowdown, Natural flow, Produced gas – on Marcet
4440	4560	1029.5	1592.6	55062	7435.6	4347.6	3171.9	191.41	1.3445	2.44E-06	0	
4560	4680	1328.6	2028.1	70490	9674.2	5703	4107.7	236.12	1.4634	1.71E-06	0	
4680	4800	1083.6	1633.9	57071	7956.5	4733.8	3359.2	186.55	1.0469	8.30E-07	0	
4800	4920	266.03	397.01	13936	1964.7	1177.3	825.71	45.149	0.2388	1.56E-07	0	
4920	5040	51.053	76.918	2677.2	378.9	228.07	159.04	8.7083	0.0447	2.70E-08	0	
5040	5160	15.467	22.749	806.12	114.67	69.049	47.947	2.631	0.0133	7.64E-09	0	
5160	5280	6.8333	9.9822	355.32	50.66	30.522	21.151	1.16	0.0058	3.29E-09	0	
5280	5400	3.3926	4.9884	176.64	25.192	15.198	10.52	0.577	0.0029	1.61E-09	0	
5400	5480	1.5955	2.3572	83.162	11.862	7.1618	4.9538	0.2717	0.0013	7.53E-10	0	

Table 14 “Gas To Process”

T1	T2	CO2	N2	C1	C2	C3	C4-6	C7+1	C7+2	C7+3	H20	Recover y
d	d	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	
0	120	0	0	0	0	0	0	0	0	0	0	Depletion, 6 producers 15000Mscf/d
120	240	0	0	0	0	0	0	0	0	0	0	
240	360	0	0	0	0	0	0	0	0	0	0	
360	480	0	0	0	0	0	0	0	0	0	0	
480	600	0	0	0	0	0	0	0	0	0.00E+00	0	
600	720	286.48	554.45	17393	1832.9	946.57	648.46	275.83	1.6125	9.03E-05	0	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mcsf/d. FIGR=60000Mscf/d. Retrograde Condensate Vaporized by Multi Contact Misciable Gas Cycling
720	840	316.05	619.5	19312	2004.8	1024.6	715.32	303.9	1.7462	7.23E-05	0	
840	960	312.26	614.01	19117	1972.2	1001.4	707.95	296.93	1.6906	5.99E-05	0	
960	1080	328.58	646.21	20126	2068.7	1044.4	746.28	308.69	1.7414	5.31E-05	0	
1080	1200	332.42	649.56	20304	2091.7	1050.9	755.76	307.29	1.7167	4.63E-05	0	
1200	1320	332.77	639.67	20162	2102.8	1054.3	756.72	300.39	1.6615	4.06E-05	0	
1320	1440	327.46	614.61	19595	2088.3	1050.1	745.52	286.48	1.5693	3.51E-05	0	
1440	1560	365.5	668	21558	2359.8	1195.9	835.29	308.22	1.6732	3.42E-05	0	
1560	1680	398.28	708.96	23154	2605.9	1335	916.33	322.52	1.7363	3.16E-05	0	
1680	1800	394.33	685.35	22626	2612.2	1353.6	914.95	306.37	1.6394	2.57E-05	0	
1800	1920	413.48	702.9	23440	2770.6	1451.3	968.36	307.71	1.6443	2.17E-05	0	
1920	2040	444.76	741.47	24947	3010.2	1591.8	1051.3	317.03	1.7044	1.87E-05	0	
2040	2160	417.72	684.31	23207	2852.8	1521.4	996.8	284.69	1.5538	1.46E-05	0	
2160	2280	451.85	729.13	24896	3110.7	1671.6	1088.6	294.22	1.6448	1.33E-05	0	
2280	2400	473.16	753.58	25881	3280.9	1775.6	1151.2	294.02	1.6948	1.18E-05	0	
2400	2520	486.31	765.86	26431	3394.2	1849.5	1195.3	288.15	1.719	1.02E-05	0	
2520	2640	524.83	818.45	28364	3685.3	2021.6	1303.8	296.25	1.8311	9.29E-06	0	
2640	2760	502.1	775.31	26988	3543.6	1952.6	1250.9	277.5	1.7503	7.55E-06	0	
2760	2880	172.11	250.01	9032.6	1201.9	634.9	376.53	153.48	0.6972	2.25E-06	0	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mcsf/d. FIGR=80000Mscf/d. Retrograde Condensate Vaporized by first Contact Misciable Gas Cycling
2880	3000	169.7	250.76	8980.2	1178.4	619.93	372.22	151.22	0.7015	2.13E-06	0	
3000	3120	166.81	246.44	8816.6	1165.4	618.23	367.94	146.23	0.6908	2.05E-06	0	
3120	3240	165.78	243.13	8721.7	1168.3	626.78	368.29	142.01	0.6796	2.04E-06	0	
3240	3360	159.94	231.96	8358.9	1137.6	615.35	356.93	133.78	0.6447	2.02E-06	0	
3360	3480	181.98	260.69	9439.4	1308.1	713.48	407.6	148.5	0.7193	2.35E-06	0	
3480	3600	170.95	242.23	8805.5	1242	684.29	384.72	135.96	0.6655	2.22E-06	0	
3600	3720	173.52	243.91	8889.3	1272.5	708.77	393.03	134.44	0.6709	2.21E-06	0	
3720	3840	185.14	258.82	9446.9	1368.4	770.67	422.81	139.5	0.7157	2.33E-06	0	
3840	3960	198.27	276.38	10092	1473.7	837.82	456.66	145.34	0.7691	2.48E-06	0	
3960	4080	195	271.54	9912	1455.4	833.87	452.99	139.08	0.7595	2.45E-06	0	
4080	4200	192.3	267.83	9769.1	1439.3	829.7	450.26	133.7	0.7505	2.45E-06	0	
4200	4320	0	0	0	0	0	0	0	0	0	0	
4320	4440	0	0	0	0	0	0	0	0	0	0	Blow down, Natural flow, Produced gas - on Marcet
4440	4560	0	0	0	0	0	0	0	0	0	0	
4560	4680	0	0	0	0	0	0	0	0	0	0	
4680	4800	0	0	0	0	0	0	0	0	0	0	
4800	4920	0	0	0	0	0	0	0	0	0	0	
4920	5040	0	0	0	0	0	0	0	0	0	0	
5040	5160	0	0	0	0	0	0	0	0	0	0	
5160	5280	0	0	0	0	0	0	0	0	0	0	
5280	5400	0	0	0	0	0	0	0	0	0	0	
5400	5480	0	0	0	0	0	0	0	0	0	0	

Table 15 “Cycling Gas stream”

T1	T2	CO2	N2	C1	C2	C3	C4-6	C7+1	C7+2	C7+3	H20	Recovery
d	d	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	
0	120	0	6.1999	762.71	593.17	771.06	635.08	158.94	1.3458	0.000852	0	Depletion, 6 producers 15000Mscf/d
120	240	0	11.162	1367.2	1054.5	1375.5	1163	282.62	2.4406	0.00108	0	
240	360	0	5.8952	718.76	549.6	719.41	627.71	145.88	1.268	0.000372	0	
360	480	0	5.5843	678.01	514.15	675.06	610.52	133.39	1.1477	2.16E-04	0	
480	600	0	3.3679	407.55	306.91	403.88	378.41	76.922	0.644	8.16E-05	0	
600	720	0	2.8563	332.92	228.94	308.55	316.93	137.25	0.8051	4.51E-05	0	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mscf/d. FIGR=60000Mscf/d. Retrograde Condensate Vaporized by Multi Contact Misciable Gas Cycling
720	840	0	3.1039	360.27	245.43	330.46	349.31	151.19	0.8718	3.61E-05	0	
840	960	0	3.0369	352.44	239.21	321.4	345.58	147.72	0.844	2.99E-05	0	
960	1080	0	3.1687	368.1	249.37	334.11	364.19	153.56	0.8694	2.65E-05	0	
1080	1200	0	3.1845	371.31	252.11	336.16	368.82	152.86	0.857	2.31E-05	0	
1200	1320	0	3.1845	373.97	256.27	339.23	369.46	149.44	0.8295	2.03E-05	0	
1320	1440	0	3.158	374.21	260.39	341.93	364.33	142.54	0.7835	1.75E-05	0	
1440	1560	0	3.581	428.18	303.37	395.61	408.7	153.39	0.8353	1.71E-05	0	
1560	1680	0	3.9821	480.19	346.41	449.22	448.93	160.54	0.8669	1.58E-05	0	
1680	1800	0	4.0238	488.91	358.41	462.7	448.77	152.53	0.8185	1.28E-05	0	
1800	1920	0	4.3011	526.32	391.48	503.29	475.45	153.22	0.8209	1.08E-05	0	
1920	2040	0	4.7053	579.41	436.39	558.88	516.63	157.88	0.8509	9.32E-06	0	
2040	2160	0	4.4874	555.69	423.21	540.04	490.19	141.8	0.7757	7.28E-06	0	
2160	2280	0	4.9219	612.4	470.92	599.02	535.67	146.56	0.8212	6.65E-06	0	
2280	2400	0	5.2209	652.2	505.75	641.64	566.77	146.47	0.8461	5.89E-06	0	
2400	2520	0	5.4321	680.83	531.85	673.35	588.77	143.56	0.8582	5.11E-06	0	
2520	2640	0	5.9322	745.56	586.23	741.06	642.47	147.6	0.9142	4.64E-06	0	
2640	2760	0	5.7228	721.39	570.66	719.73	616.63	138.26	0.8738	3.77E-06	0	
2760	2880	0	0.4987	65.015	52.171	63.511	50.675	20.887	0.0951	3.06E-07	0	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mscf/d. FIGR=80000Mscf/d. Retrograde Condensate Vaporized by first Contact Misciable Gas Cycling
2880	3000	0	0.4888	63.291	50.366	61.583	50.074	20.577	0.0957	2.90E-07	0	
3000	3120	0	0.4881	63.06	50.363	61.723	49.513	19.9	0.0942	2.79E-07	0	
3120	3240	0	0.4945	63.938	51.416	63.092	49.586	19.326	0.0927	2.78E-07	0	
3240	3360	0	0.4853	62.887	51.019	62.463	48.081	18.208	0.0879	2.75E-07	0	
3360	3480	0	0.5627	73.087	59.899	73.085	54.935	20.213	0.0981	3.21E-07	0	
3480	3600	0	0.5398	70.205	58.086	70.735	51.879	18.507	0.0907	3.02E-07	0	
3600	3720	0	0.5591	72.744	60.635	73.852	53.024	18.303	0.0915	3.02E-07	0	
3720	3840	0	0.6078	79.056	66.262	80.848	57.063	18.992	0.0976	3.17E-07	0	
3840	3960	0	0.6606	85.859	72.214	88.328	61.65	19.788	0.1049	3.38E-07	0	
3960	4080	0	0.6575	85.356	71.94	88.233	61.167	18.936	0.1036	3.34E-07	0	
4080	4200	0	0.6543	84.832	71.576	88.012	60.807	18.204	0.1023	3.34E-07	0	
4200	4320	0	6.8352	859.93	693.28	881.48	725.97	123.07	0.9281	3.42E-06	0	
4320	4440	0	16.115	2021.1	1602.3	2069.2	1984.8	128.15	0.9969	2.62E-06	0	Blowdown, Natural flow, Produced gas - on Marcet
4440	4560	0	25.66	3219	2569.7	3311.4	3137.8	191.08	1.3445	2.44E-06	0	
4560	4680	0	33.594	4226.8	3404.5	4377.1	4065.3	235.74	1.4634	1.71E-06	0	
4680	4800	0	27.821	3509.6	2850.5	3660.3	3325.9	186.26	1.0469	8.30E-07	0	
4800	4920	0	6.8969	872.85	713.02	915.2	817.76	45.081	0.2388	1.56E-07	0	
4920	5040	0	1.3462	168.85	138.19	177.65	157.52	8.6952	0.0447	2.70E-08	0	
5040	5160	0	0.4015	51.22	42.034	53.894	47.496	2.6271	0.0133	7.64E-09	0	
5160	5280	0	0.1768	22.653	18.613	23.845	20.953	1.1583	0.0058	3.29E-09	0	
5280	5400	0	0.0884	11.271	9.2613	11.877	10.422	0.5762	0.0029	1.61E-09	0	
5400	5480	0	0.0418	5.3085	4.3622	5.5974	4.9075	0.2713	0.0013	7.53E-10	0	

Table 16 "NGL stream"

T1	T2	CO2	N2	C1	C2	C3	C4-6	C7+1	C7+2	C7+3	H20	Recovery
d	d	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	kgmole/h	
0	120	0	420.27	13714	1267.9	278.9	8.3322	0.3247	6.53E-08	1.29E-18	0	Depletion, 6 producers 15000Mscf/d
120	240	0	774.71	25136	2304.8	510.37	15.757	0.5968	1.22E-07	1.67E-18	0	
240	360	0	418.97	13507	1227.7	273.61	8.7721	0.3182	6.52E-08	5.87E-19	0	
360	480	0	405.73	13001	1171.4	262.5	8.7705	0.2994	6.06E-08	3.47E-19	0	
480	600	0	249.02	7937.8	709.77	159.68	5.5485	0.1764	3.47E-08	1.33E-19	0	
600	720	0	273.95	8350.6	686.13	164.03	6.8127	0.4622	5.73E-08	7.59E-20	0	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mcsf/d. FIGR=60000Mscf/d. Retrograde Condensate Vaporized by Multi Contact Misciable Gas Cycling
720	840	0	306.18	9281.2	755.47	181.05	7.8088	0.5303	6.42E-08	6.19E-20	0	
840	960	0	303.51	9191.7	745.4	178.52	7.865	0.528	6.33E-08	5.19E-20	0	
960	1080	0	319.45	9679.7	783.45	187.29	8.3885	0.5559	6.60E-08	4.64E-20	0	
1080	1200	0	321.11	9765.7	792.16	188.48	8.4981	0.5538	6.52E-08	4.08E-20	0	
1200	1320	0	316.17	9692.1	793.53	187.11	8.3354	0.5301	6.22E-08	3.58E-20	0	
1320	1440	0	303.69	9408.4	782.22	182.3	7.8664	0.4834	5.68E-08	3.07E-20	0	
1440	1560	0	329.92	10335	874.77	201.42	8.314	0.4895	5.78E-08	2.95E-20	0	
1560	1680	0	349.96	11080	954.58	217.28	8.5472	0.4788	5.69E-08	2.68E-20	0	
1680	1800	0	338.14	10807	945.74	213.06	8.0195	0.4264	5.10E-08	2.14E-20	0	
1800	1920	0	346.62	11176	991.76	221.25	8.005	0.4032	4.88E-08	1.78E-20	0	
1920	2040	0	365.48	11875	1066.5	235.8	8.2522	0.3938	4.85E-08	1.51E-20	0	
2040	2160	0	337.15	11031	1001.1	219.51	7.4654	0.337	4.26E-08	1.16E-20	0	
2160	2280	0	359.1	11817	1082.1	235.53	7.8199	0.3338	4.36E-08	1.05E-20	0	
2280	2400	0	371.01	12269	1132.2	244.84	7.9638	0.321	4.36E-08	9.22E-21	0	
2400	2520	0	376.93	12515	1162.7	250	7.9897	0.3037	4.30E-08	7.93E-21	0	
2520	2640	0	402.68	13415	1253.7	268.21	8.44	0.3023	4.47E-08	7.14E-21	0	
2640	2760	0	381.35	12753	1198.5	255.12	7.8898	0.2757	4.18E-08	5.75E-21	0	
2760	2880	0	33.594	1166.7	111.73	23.066	0.6699	0.0427	4.50E-09	4.26E-22	0	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mcsf/d. FIGR=80000Mscf/d. Retrograde Condensate Vaporized by first Contact Misciable Gas Cycling
2880	3000	0	33.706	1161.3	110.32	22.952	0.684	0.0435	4.66E-09	4.10E-22	0	
3000	3120	0	33.118	1139.2	108.56	22.581	0.6604	0.0411	4.50E-09	3.92E-22	0	
3120	3240	0	32.66	1125.4	107.9	22.378	0.6358	0.0383	4.29E-09	3.86E-22	0	
3240	3360	0	31.145	1077	104.11	21.448	0.5917	0.0346	3.93E-09	3.76E-22	0	
3360	3480	0	34.986	1214.1	118.48	24.208	0.6461	0.0367	4.23E-09	4.32E-22	0	
3480	3600	0	32.492	1130.5	111.28	22.577	0.5823	0.0321	3.77E-09	4.00E-22	0	
3600	3720	0	32.701	1139.4	112.88	22.799	0.5706	0.0304	3.67E-09	3.94E-22	0	
3720	3840	0	34.686	1209.2	120.34	24.244	0.592	0.0304	3.80E-09	4.09E-22	0	
3840	3960	0	37.027	1290.3	128.75	25.919	0.6223	0.0308	4.00E-09	4.31E-22	0	
3960	4080	0	36.37	1266.3	126.52	25.477	0.605	0.0289	3.88E-09	4.24E-22	0	
4080	4200	0	35.869	1247.3	124.69	25.129	0.5928	0.0274	3.80E-09	4.22E-22	0	
4200	4320	0	417.82	13969	1332.9	281.81	8.1433	0.215	4.00E-08	5.00E-21	0	
4320	4440	0	1004.9	33214	3098.1	663.39	22.235	0.2246	4.37E-08	4.04E-21	0	Blowdown, Natural flow, Produced gas - on Marcet
4440	4560	0	1566.9	51843	4865.8	1036.1	34.085	0.3245	5.74E-08	3.71E-21	0	
4560	4680	0	1994.5	66263	6269.7	1325.9	42.393	0.3841	6.03E-08	2.55E-21	0	
4680	4800	0	1606.1	53561	5106.1	1073.4	33.299	0.2911	4.16E-08	1.21E-21	0	
4800	4920	0	390.11	13063	1251.7	262.13	7.9481	0.0683	9.25E-09	2.23E-22	0	
4920	5040	0	75.571	2508.4	240.71	50.416	1.5131	0.013	1.71E-09	3.83E-23	0	
5040	5160	0	22.347	754.9	72.64	15.156	0.4512	0.0039	5.03E-10	1.08E-23	0	
5160	5280	0	9.8054	332.66	32.048	6.6772	0.198	0.0017	2.19E-10	4.63E-24	0	
5280	5400	0	4.9	165.37	15.93	3.3216	0.0983	0.0008	1.08E-10	2.27E-24	0	
5400	5480	0	2.3154	77.853	7.4996	1.5645	0.0463	0.0004	5.07E-11	1.06E-24	0	

Table 17 "LNG stream"

Stream		Productior	Condensat	Dry Gas	To Process	Cycle Ga	NGL	LNG	VGD, C/V
T1	T2	Rate	Rate	Rate	Rate	Rate	Rate	Rate	Recovery
d	d	Sm3pd	Sm3pd	Sm3pd	Sm3pd	Sm3pd	Sm3pd	Sm3pd	
0	120	512855	420.72	444542	446458.94	0	69243	370979	Depletion, 6 producers 15000Mscf/d
120	240	491113	333.78	434622	436478.19	0	65460	364990	
240	360	465940	283.76	416990	418764.08	0	61898	351112	
360	480	280932	153.63	253984	255061.08	0	37303	214266	
480	600	280932	153.63	253984	255061.08	0	37303	214266	
600	720	910289	835.67	774570	258984.73	518747	31406	224197	Gas Cycling, 6 Producers and 2 injectors. FGPR=90000Mcsf/d. FIGR=60000Mscf/d. Retrograde Condensate Vaporized by first Contact Miscible Gas Cycling
720	840	1000509	874.16	857846	286822.70	574507	34063	249029	
840	960	982764	820.95	848167	283583.48	568019	33344	246553	
960	1080	1027895	824.04	892198	298302.89	597502	34837	259587	
1080	1200	1031779	796.09	900085	300939.65	602783	35119	261896	
1200	1320	1021832	762.51	895024	299250.29	599399	35287	260035	
1320	1440	993136	721.90	872342	291672.68	584221	35168	252640	
1440	1560	1095050	780.52	963547	322176.64	645321	40046	277816	
1560	1680	1179874	827.47	1E+06	347559.75	696163	44692	298167	
1680	1800	1156682	799.29	1E+06	341083.26	683191	45307	291122	
1800	1920	1201850	818.05	1E+06	354792.12	710650	48587	301325	
1920	2040	1282203	859.26	1E+06	378982.08	759102	53312	320420	
2040	2160	1195033	787.36	1E+06	353737.90	708538	50982	297825	
2160	2280	1283791	831.11	1E+06	380621.10	762385	56044	319243	
2280	2400	1335941	849.31	1E+06	396756.91	794705	59558	331614	
2400	2520	1365461	852.33	1E+06	406221.62	813663	62058	338423	
2520	2640	1466320	898.78	1E+06	436959.65	875231	67854	362910	
2640	2760	1399706	865.38	1E+06	416603.31	834458	65572	345104	
2760	2880	390301	444.97	316264	38117.94	279532	5978.6	31584	Gas Cycling, 6 Producers and 4 injectors. FGPR=90000Mcsf/d. FIGR=80000Mscf/d. Retrograde Condensate Vaporized by first Contact Miscible Gas Cycling
2880	3000	385322	431.22	313616	37797.97	277185	5827.8	31423	
3000	3120	378246	419.24	308403	37170.08	272581	5796.2	30836	
3120	3240	374793	411.90	305945	36874.58	270414	5862.5	30478	
3240	3360	359873	391.90	294126	35450.85	259973	5751	29184	
3360	3480	407374	439.68	333318	40175.49	294620	6664.9	32924	
3480	3600	381094	408.30	312066	37614.90	275843	6385	30679	
3600	3720	385728	410.76	316067	38098.00	279385	6601.7	30937	
3720	3840	410687	434.23	336840	40602.74	297753	7162.5	32843	
3840	3960	438986	459.84	360585	43465.60	318748	7769.7	35057	
3960	4080	430922	445.99	354691	42755.50	313540	7717.4	34409	
4080	4200	424128	432.97	349934	42182.41	309338	7665.2	33897	
4200	4320	514837	296.63	460948	462977.27	0	77826	378547	
4320	4440	1173837	408.34	1E+06	1099006.44	0	184961	898558	Blowdown, Natural flow, Produced gas - on Marcet
4440	4560	1843094	655.88	2E+06	1722062.10	0	294517	1E+06	
4560	4680	2377103	885.74	2E+06	2212383.18	0	386455	2E+06	
4680	4800	1940851	765.33	2E+06	1797574.91	0	320651	1E+06	
4800	4920	477131	197.15	438098	440068.94	0	79707	354072	
4920	5040	91967.3	38.88	84266	84645.98	0	15423	68016	
5040	5160	27750.7	11.92	25389	25504.14	0	4674.2	20464	
5160	5280	12245.7	5.30	11195	11246.02	0	2066.6	9017.8	
5280	5400	6091.8	2.65	5567	5592.15	0	1028.5	4483.4	
5400	5480	2869.13	1.25	2621.3	2633.16	0	484.47	2111	

Table 18 “Std Volume Rate”