Analytic Study for Subsea Oil Production Optimization Using Lean Concepts

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Abstract

Oil & gas production is intensive cost activity due to the high cutting-edge technologies and energy requirements. In addition to the global continuous increase in power demands and due to the correlation of oil prices with global events which makes the price vulnerable to rapid fluctuation; most oil and gas companies tend to increase the production for the same oil field above the initial forecasting limit to increase the total profit in terms of monetary value during the oil wells' life. Nevertheless, the oil overproduction has negative impacts on the company main assets such as wells equipment damage, high wells depletion rate, high power consumption, high wastewater, low product quality and adverse environmental impact; which will make the operation and maintenance cost to be much higher than the production increasing revenues. As the Lean management system concepts and tools are well known in the oil and gas industry and already in use in several operations improvement projects. So, in this research, a new model is suggested to be readily used by any oil and gas company to solve the problem by using Lean concepts and tools such as Value stream mapping "VSM", Value Analysis, Method Study and Analytic Hierarchy Process "AHP" to eliminate wastes and concentrate the main values of the operations that lead ultimately to an acceptable increase in profits while not causing the mentioned overproduction problems.

Keywords

Lean, Overproduction, Production Scenario, Value Stream Mapping.

1. Introduction.

Most oil & gas production companies tended to increase their oil and gas production much higher than the initial forecasting limits, this case had been known as oil overproduction (Maugeri 2012) the reasons behind this overproduction are.

1- Exploration Success Levels in Searching for and producing oil is Less Than 30% (Prince and de la Harpe 2015) which makes the oil joint ventures always a Risky business due to uncertainty, oil and gas companies are one of the big 5 industries with the most bankruptcy filling in the last year 2020 (SHEN 2020).
2- The sudden changing world oil price has a tremendous effect on the oil and gas companies economy. In April 2020, the price of the main U.S. oil benchmark fell to about $30 below zero (Reed and Krauss 2020), which underscores the oil and gas industry's economic risk as the coronavirus COVID-19 pandemic decimates the world economy.
3- Oil production expense recovery or the Break-Even point is a long-term process that can be reached 10 years in some mega projects and the total production period can reach 50 years or more (D. Babusiaux (IFP) 2007). The oil and gas companies tend to increase investments gradually as the price of crude oil increases, but once the new investments are started, they are very difficult to stop, even when consumption and crude oil prices suddenly collapse. especially when hundreds of millions of dollars have already been spent (Maugeri 2012).
4- Contractual commitments are made by the oil companies with the countries owning the deposits, which often make it difficult to block or reduce the spending. Indeed, these commitments demand heavy economic penalties or even revocation of the concessions granted by the host government if, by pre-established dates, the agreed number of wells and the needed infrastructure are not realized, and initial production is not achieved (Hutabarat 2015).

5- Although the reservoir simulations forecasting scenario is the best scenario for optimum production with the lowest amount of operational wastes (Hyne 2012). However, most companies tend to increase the oil production above the forecasting scenarios under the economic and markets pressure; this was always supported by the fact that during the first years of exploration and production, estimates of oil contained in an oilfield tend to be incomplete and conservative which can make some arguments about the forecasting process. This explains why resources increase over time in tandem with increased knowledge, and this explained too why the oil companies preferer to increase the production above the initial forecasting (Maugeri 2012).

6- Increasingly global power demand and the market stress, even before the COVID-19 pandemic and its impact on the energy system and CO2 emissions, the power sector was amidst a dynamic transformation process with increasing demand. While fossil fuels (oil, gas and coal) are used to generate the most power in most countries, the world oil consumption before the COVID-19 pandemic was increased up to 100 million barrels per day (Bertram, Luderer, et al. 2021).

Thus, many oil companies can argue that the oil overproduction high rate that exceeding the initial forecasting higher limits- especially when that forecasting is not that accurate- can have a lot of benefits such as quickly respond to the economic stresses and responding to the increasing market demand, but unfortunately; those benefits won't last much.

In other words, what are the harms of oil overproduction? to answer this question it must be known that the benefits of oil overproduction are temporarily, and sooner become losses.

To understand this claim; an example case will be studied, a global oil company discovered in the year 2000, the initial daily oil production rate was forecasted as nominal 53,300 barrels of oil per day (bbls/d) for around 22 years with normal production decline, the total expected amount of oil around 152 million barrels as shown in Figure 1 the oil processing plant capacity was 66,000 barrels of oil per day

By March 2003 the plant has been started to produce oil, by the end of 2004 the oil production has been reached its overproduction peak that was around 90,000 bbls/d. Early in 2005 some successive problems happened to the oil wells and the processing plants due to this overproduction that made the company spend millions of dollars for fixation and maintenance of the wells and the processing plant, but the production never got back to the initial forecasting, instead, the oil filed depleted completely after only 15 years with total production amount of 127 million barrels in the whole period as per Figure 1 shows the curve of actual daily production, forecasting curve and the plant capacity verse time.

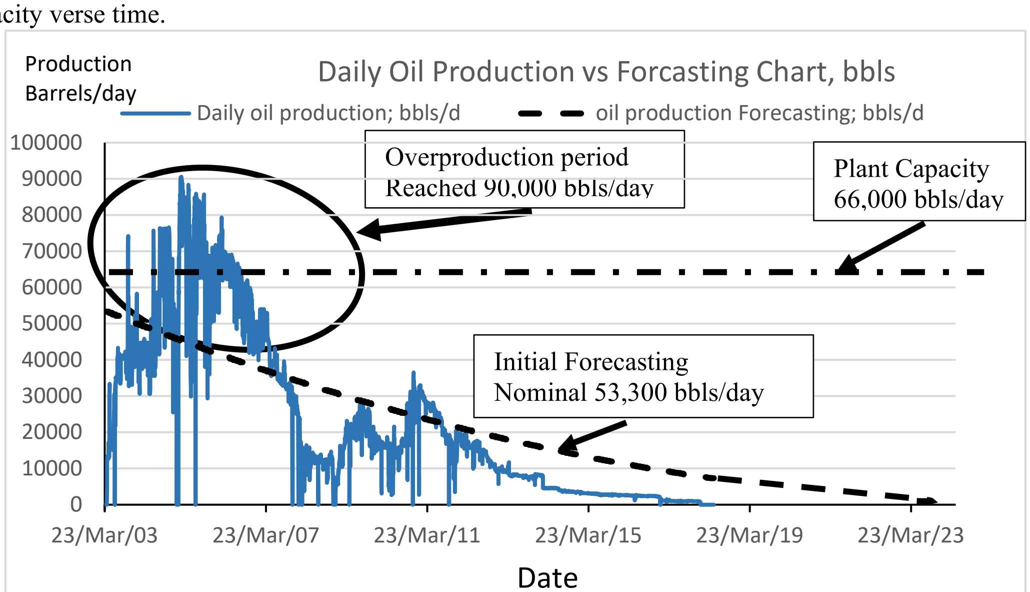


Figure 1. Company actual oil production rate history
Source: Company data

Adverse Impact of Overproduction

From the company reports; some serious problems into the companies' assets and operations wastes happened to the company field and could happen to any other oil company due to overproduction, those problems will decrease in the long term the benefits of oil and gas overproduction, those problems were as follow:

1. Poor products quality
2. More power consumption and give off more environmental wastes
3. High pressure / production decline for the oil wells.

4. Quick field depletion
5. High produced associated water problem
6. Equipment and Mechanical parts repeated failures
7. The need for plant modifications and Debottlenecking needed for increase the plant capacity

In the following figure 2, shows some damaged happened to the company equipment due to the oil overproduction, the figure shows a damage happened in the wells choke and Sand accumulation inside the gas separator.

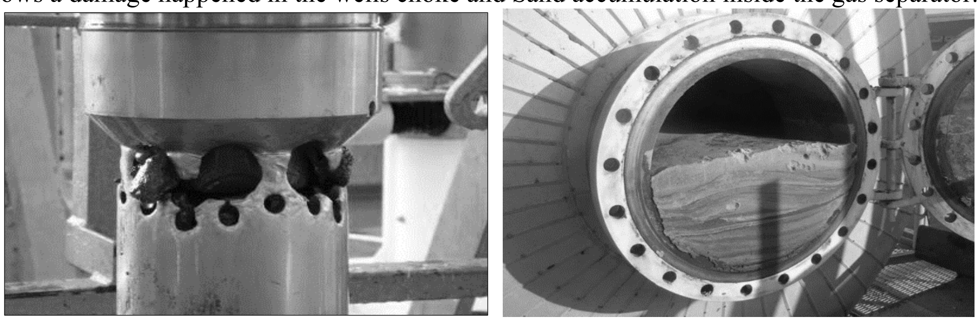


Figure 2. some damaged happed to the company equipment due to oil overproduction
Source: Company oil field

2. Objective.

As the lean system is well known in oil and gas industry, and using in several improvement projects and day to day activities (Rohan Sakhardande 2011); a Lean based model is proposed to improve the company operations values, eliminate any operations wastes by avoid overproduction problems using lean tools such as Method Study, Value Stream Mapping VSM, Value Analysis, Decision Tree and Analytic Hierarchy Process AHP along with economic & financial calculation of best alternatives by choosing appropriate high production profile. So, this model can be readily used by oil and gas companies to increase the company monetary values of its oil production and keep other operations values within a reasonable level with all operations wastes removed.

3. Literature Review.

In the oil and gas industry, there are several tools associated with lean operations and more are proposed every day in the workplaces (Rohan Sakhardande 2011); from among the already used lean tools are 5S, TPM, Kaizen, Visual workplace, Method study and analysis the value Stream Mapping “VSM” and value analysis (Mandloi and Yadav 2014) and (Maria, Cabral, et al. 2011). Oil production passes with successive stages from exploration to the wells drilling and completion until the oil processing, refinery and final product marketing (Håvard Devold 2013). Oil and gas reservoirs are the subsurface structure that contains the oil and gas in the porous or fractured rock formation; there are several types and shapes of the reservoirs that can be found and located using the oil and gas exploration methods (Loera 2015). The principal function of reservoir engineering is to predict the future performance of the oil reservoir by developing optimum production scenarios for the oil and gas under producing mechanisms depletion strategies (Iyke and Princewill 2018). the relationship between the oil reservoir production and the time is Hyperbolic Curve called Production Decline Curve (Darwis, Ruchjana, et al. 2012) and (Seidle 2018).
Production Decline curve analysis and forecasting simulation is the method that determines the future life of a well by extrapolation the decline curve by plotting variable production rate against time (J.J. Arps 1945) as shown in Figure 7. Although Reservoir Engineering is the sole method to predict the oil wells behavior and future production trend (Loera 2015)(Havlena and Odeh 1963), most companies tend to overproduce oil higher than the forecasting scenarios due to the economic stress and the market demand; this was always supported by the fact that during the first years of exploration and production, estimates of oil contained in an oilfield tend to be incomplete and conservative which can make some arguments about the forecasting process (Maugeri 2012) making the oil overproduction is well known in several oil companies.

4. Method.

The research introduces a model that can be readily used by any oil and gas company that needs to increase its oil production much higher than the forecasting limits under the economic pressure and market demand, and in the same time need to mitigate the oil overproduction problem, the model is using lean concepts of improving operations values such as wells life, monetary value and total recovery; and at the same time removing the wastes of the overproduction, the lean tools used are value stream mapping, value analysis, Method study and analytic hierarchy process AHP.
the research studied analytically the effect of oil overproduction within a subsea oil production system by studying different oil production scenarios from the subsea production simulation system “production decline simulation PDC’ to test, run and put sustainable approach for the model.

Why the Lean system is the proposed solution? For many reasons:

1. The Lean management system concepts and tools are well known in the oil and gas industry and already in use in several operations improvement projects (Rohan Sakhardande 2011)
2. With the current oil price crisis that started in 2014 (Prince and de la Harpe 2015) In addition, the need for a lean environment and a decrease the emissions. those issues put some pressure on the oil and gas companies to optimize their operations using more lean tools to adopt more efficient effective lean management systems to get more from less (Bereznoy 2015)
3. The problem literally is an overproduction problem, whereas overproduction is one of the Lean systems wastes that must be eliminated, moreover overproduction waste is considered the worst type of waste because it hides and causes the other wastes (Milward, Gilless, et al. 2013).Taiichi Ohno one of the Japanese Lean system leaders believed that this type of waste is the most crucial of wastes as it is the root of so many problems and other wastes (Natasya, Wahab, et al. 2013).

5. Data Collection.

The case study is for a global oil company in the North Sea in whose using subsea production system of eight subsea wells in a water depth of 850 m, the produced oil transferred to an onshore processing plant with a nominal capacity was 66,000 barrels of oil per day ‘bbls/d’.
The subsea oil reservoir was discovered in the year 2000 with a total recoverable oil amount of 152 million barrels. The processing plant capacity was designed based on 66,000 bbls/day and the initial forecasting profile for the production calculated using pressure decline curves PDC Simulation was nominal 53,300 bbls/day with a normal decline for around 22 years as shown in Figure 1
By June 2004 and due to the high oil demands from the international market synchronously with the oil price increase from 35 $/barrel to 50 $/barrel. the company increased the daily production to be around 75,000 bbls/day which was much higher than the plant capacity. In January 2005 the company carried out a debottlenecking project to increase the plant capacity to be 90,000 bbls/day. But reversely the production declined dramatically due to the overproduction in that last period and the wells went through several maintenance projects to keep production with a total cost of 500 million dollars but failed, the wells depleted at the end of years 2017 as shown in figure 2, with around 15 years instead of 22 years as per predicted before, with total produced oil of 127 million barrels instead of total recoverable of 152 million barrels as per predicted as shown in Figure 1
To test and run the model; some high rate production scenarios have been proposed that are higher than the forecasting limit, lower than the processing plant capacity to will eliminate all those overproduction problems, those rates have been: 56, 58, 60, 64, 66 thousand bbls/day, the results have been predicted by using pressure decline curve simulation to predict the total production period, total oil recovery amount. All the above data has been provided by the company including all the required simulated production rate scenarios.

6. Model description

6.1. Model Preparations

The steps of the model's preparations are simplified on the following diagram as shown in the Figure 3

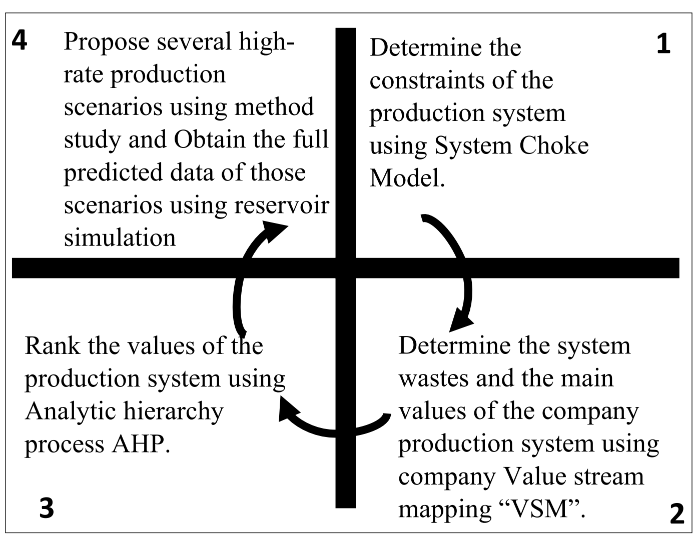


Figure 3. Model Preparations steps

Step 1: Create Master production layout choke model for the production system.

The choke model is well known in the oil and gas optimization process (Palen and Goodwin 1996) and (Spencer, J. A., & Morgan 2016). The chokes are any stoppages or constraints within the system that will affect separately or together on the production of the oil which can determine initially the production system values as shown in Figure 4. The chokes are: Subsea oil reservoir, Wells, Pipelines, Process plant and Export

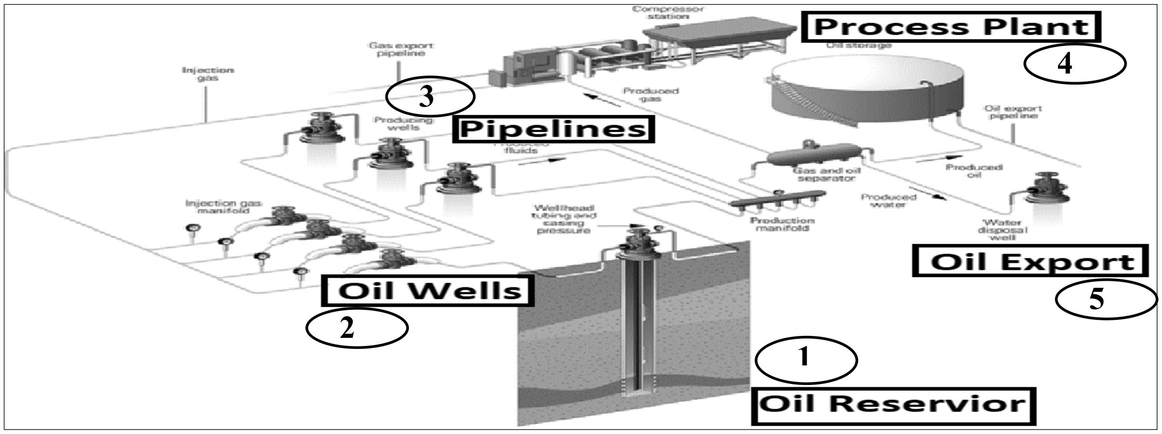


Figure 4. Subsea oil production system choke model

Step 2: Determine the main values of the company production system using company Value stream mapping "VSM".

From the production system choke model, the values can be initially estimated from the production constraints. So, the value stream mapping for the company can be introduced as per Figure 5. From the value stream mapping; the values of the production system that need to be improved in the future state as follow:

1. Total Monetary Value over the production life time, 2. Real time Production Revenue, 3. Total Recovery or total production, 4. Reservoir or Wells life.

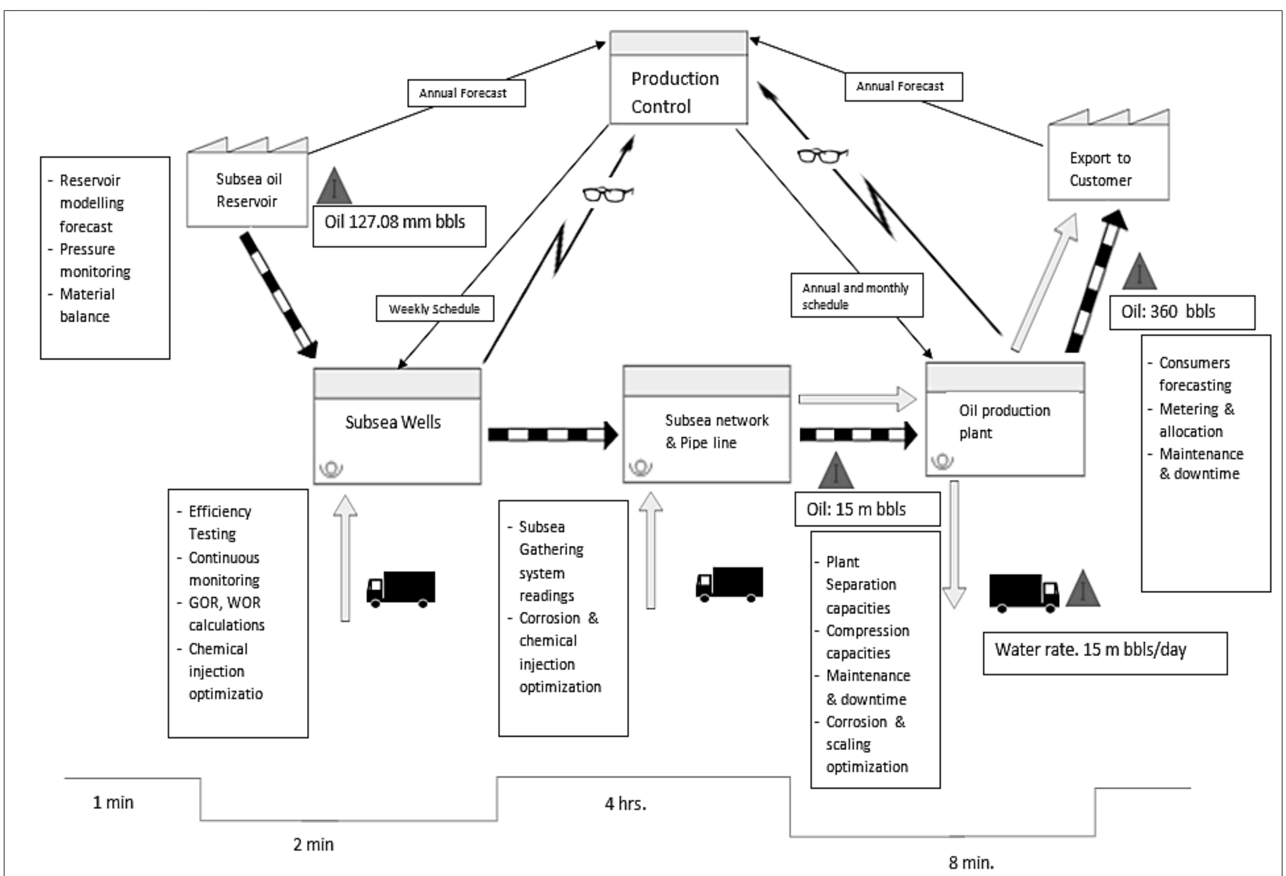


Figure 5. Subsea oil production

Step 3: Rank the values of the production system using Analytic hierarchy process AHP
After a questioner for 20 experts in oil production companies found the following criteria importance for the pre-determined values of the company production system as shown in Table 1 and Table 2.

Table 1. production system values criteria importance and preference levels based on 5-point scale.

Criterion	Symbol	Importance
Total Oil Recovery	T_r	Equal Importance
Reservoir life	n	Moderate Importance
Oil Sales Revenue	R_v	Essential Importance
Oil Sales Monetary Value	M_v	Extreme Importance

	5	4	3	2	1	2	3	4	5	
T_r						X				n
T_r							X			R_v
T_r									X	M_v
n						X				R_v
n									X	M_v
R_v									X	M_v

Table 2. Pairwise comparison normalized matrix for alternative and AHP criteria weights

Category	Pairwise				Row Avg.
	T_r	n	R_v	M_v	
T_r	0.091	0.059	0.049	0.125	0.081
n	0.182	0.118	0.073	0.125	0.124
R_v	0.273	0.235	0.146	0.125	0.195
M_v	0.455	0.588	0.732	0.625	0.60
Cl. Sum.	1.0000	1.0000	1.0000	1.0000	1.0000

Criterion	Symbol	AHP weight
Total Oil Recovery	T_r	0.080
Reservoir life	n	0.124
Oil Sales Revenue	R_v	0.195
Oil Sales Monetary Value	M_v	0.60

Step 4: Propose several high-rate production scenarios using method study decision tree.
Some proposed high production scenarios as alternatives are examined using the method study decision tree; taking into account that the proposed scenarios must not be the reason for the operations wastes stated before, that not exceed the oil well erosional velocity of the oil flow, and not exceedingly also the processing plant capacity to prevent the operations wastes into the oil wells and the oil processing plant.
For each chosen proposed scenario that passes the study decision tree; the two main data of each scenario which are the daily production and the duration of production would be estimated using production simulation, then the expected revenues and monetary values would be calculated.
The following Figure 6 shows the decision tree flow chart of the steps of examining the proposed production scenarios for high oil production required to meet oil demand under the global economic stresses.
The proposed high-rate production scenarios will be P1, P2, P3. etc.

Step 5: Obtain the full predicted data of the proposed production scenarios using reservoir production simulation
The model used in this research case study is GEM- Geological Generalize Equation of State Model Reservoir Simulator software (Joslin, Ranjbar, et al. 2020). GEM is a reservoir modeling software used to make exploration and production decisions. Based on field data and decline curve analysis. The properties of the oil reservoir are obtained from drilling core samples and production sampling of the oil.
The method determines the future life of a well by extrapolation the decline curve by plotting variable production rate against time (Shale 2017). The application of the method involves estimating a parametric model using the least-squares method and robust regression analysis. The method equation as follows (Cameselle 2010).

$$q = q_i(1 + bD_i t)^{\frac{-1}{b}} \qquad \text{Equation 1}$$

Where:

q = well's production rate at time t, bbls/day

q_i = well's production rate at time 0, bbls/day

D_i = initial nominal exponential decline rate (t = 0), 1/day

b = hyperbolic exponent

t = time, day

By using the simulation; the chosen high production oil flow rate data of daily, annual, total production and the total period of production would be estimated as per the following example table and figure as Table 5, Figure 7 and Figure 8, those date would be used as input in the model.

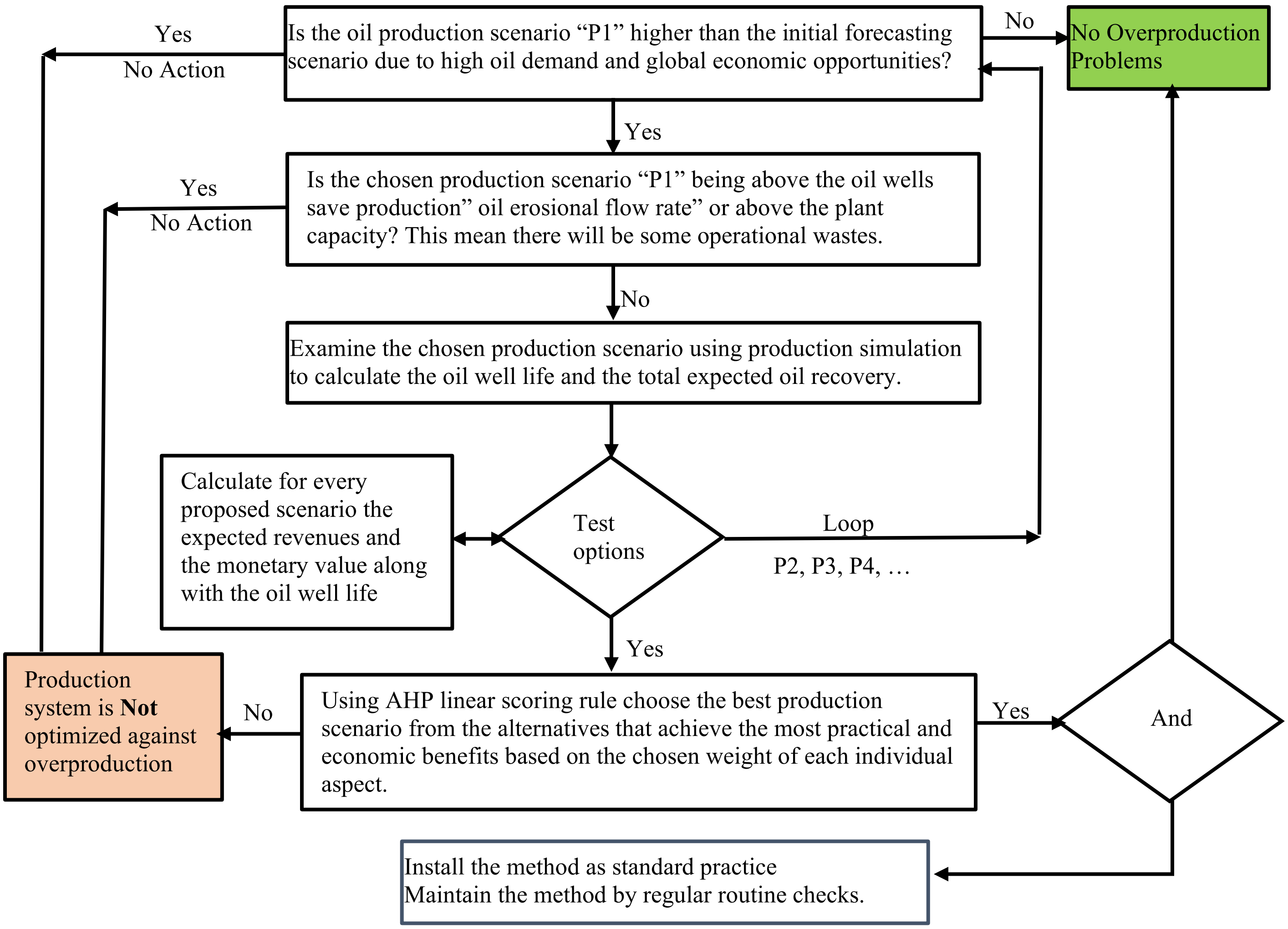


Figure 6. The proposed oil production decision tree flow chart

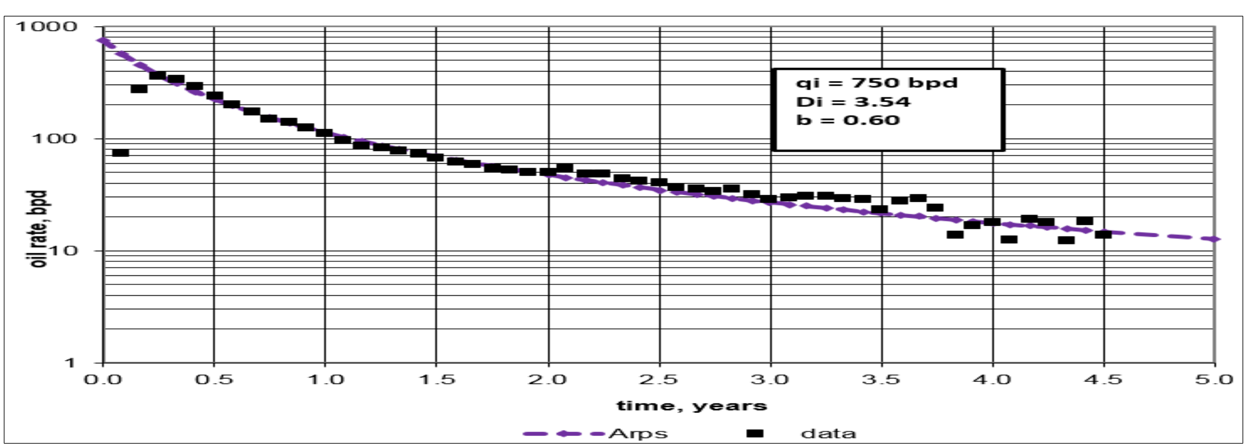


Figure 7. An example of Arps hyperbolic decline curve fit to data

Table 3. Simulation data for the proposed high-rate production scenarios

Criterion Data	Proposed high-rate production scenarios			
	P1	P2	P3	P4
Total production- Total recovery Tr	$Tr1$	$Tr2$	$Tr3$	$Tr4$
Period for production- well life n	$n1$	$n2$	$n3$	$n4$

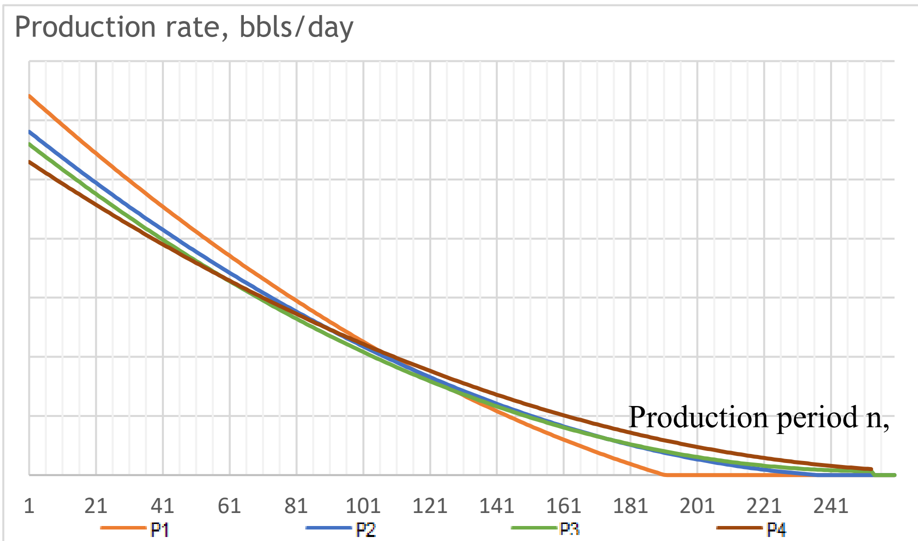


Figure 8. Example for the simulation data for the proposed high-rate production scenarios

6.2. The model formulation

A. The essential decision variables:

From the above preparation steps of values mapping and ranking, the following variables are the essential values that the model objective can be based on

1- Total Oil production or total oil recovery for certain production scenario P, Tr in barrels.

$$Tr = Q_1 + Q_2 + Q_3 + \cdots + Q_n \quad \text{Equation 2}$$

$$Tr = \sum_{j=1}^{n} Q_j \quad \text{Equation 3}$$

Where: -

$Q_1, Q_2, \ldots Q_n$ for a given production scenario P; are the total production amount in barrels of the first year, second year…. n year predicted using the production simulation.

2- Oil reservoir life or the num number of production years, $\boldsymbol{n}$ in years.

$\boldsymbol{n}$: or the reservoir life

J= 1,2, 3… n

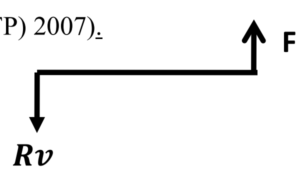
3- Total revenue Rv , in Dollars

$$\boldsymbol{Rv} = \sum_{j=1}^{n} \boldsymbol{Q_j Pr_j} \quad \text{Equation 4}$$

Where: -

$\boldsymbol{Pr}$ is the oil price in Dollars

4- Total monetary value $\boldsymbol{Mv}$, in dollars (D. Babusiaux (IFP) 2007).



$$(F/Pr, i, n) = (1+i)^K \quad \text{Equation 5}$$

$$F = Pr\,(1+i)^K \quad \text{Equation 6}$$

$$Mv = \sum_{j=1}^{n} Pr\,(1+i)^{(n-j)} \quad \text{Equation 7}$$

Where:
Rv : is the revenue or the present value of the money, in Dollars
F : is the future value of money in Dollars
i : interest rate
n : is the production period in years.
j : 1,2, 3…. n and $K = n - j$

B. Ranking of the decision variables

As shown before in the model preparation; the above-mentioned values are ranked as per Table 6.
Propose several production scenarios; As shown before in the model preparation; proposed high-rate production scenarios P1, P2, P3. etc. all are in bbls/day.

C. Predict the variables of every proposed production scenario

Using simulation as per stated before and using Equation 2 and Equation 3 in the following table

Table 4. Simulation data of total production and period of production.

Criterion Data	Proposed high-rate production scenarios			
	P1	P2	P3	P4
Total production- Total recovery $Tr = Q_1 + Q_2 + Q_3 + \cdots + Q_n$	$Tr1$	$Tr2$	$Tr3$	$Tr4$
Period for production- well life n	$n1$	$n2$	$n3$	$n4$

D. Calculations

From the above tables and Equation 6 and Equation 7 found the following table.

Table 5. calculation data of the high-rate production scenarios

Criterion	Alternative high-rate production scenarios readings					
	P1	P2	P3	P4	Max	Min
Tr	$Tr1$	$Tr2$	$Tr3$	$Tr4$	Tr_{max}	Tr_{min}
n	$n1$	$n2$	$n3$	$n4$	n_{max}	n_{min}
Rv	$Rv1$	$Rv2$	$Rv3$	$Rv4$	Rv_{max}	Rv_{min}
Mv	$Mv1$	$Mv2$	$Mv3$	$Mv4$	Mv_{max}	Mv_{min}

E. Scoring

Using the AHP linear scoring rule equation and min- max Normalization techniques (Fagin and Wimmers 2000)

Table 6. AHP linear scoring rule equation and min- max Normalization techniques

Criterion	AHP weight	P1	P2	P3	P4
Tr	0.0809	X_{1A}	X_{2A}	X_{3A}	X_{4A}
n	0.1244	X_{1B}	X_{2B}	X_{3B}	X_{4B}
Rv	0.1948	X_{1C}	X_{2C}	X_{3C}	X_{4C}
Mv	0.5999	X_{1D}	X_{2D}	X_{3D}	X_{4D}
	Sum Product	SP_1	SP_2	SP_3	SP_4

Where: -

X_{1A}: is the scoring of the P1 production regarding of the total recovery criterion (Jain, Nandakumar, et al. 2005)

$$X_{1A} = Tr_{max}\left(\frac{Tr_1 - Tr_{min}}{Tr_{max} - Tr_{min}}\right) + \left(\frac{Tr_{max} - Tr_1}{Tr_{max} - Tr_{min}}\right) \quad \text{Equation 8}$$

X_{1B}: is the scoring of the P1 production regarding the reservoir life in years as per the following equation

$$X_{1B} = n_{max}\left(\frac{n_1 - n_{min}}{n_{max} - n_{min}}\right) + \left(\frac{n_{max} - n_1}{n_{max} - n_{min}}\right) \quad \text{Equation 9}$$

And the same for the rest of the scoring in the table

F. Objective function

Choose the maximum of the sum product of SP1, SP2, SP3 and SP4

$$SP_1 = 0.0809\, X_{1A} + 0.1244\, X_{1B} + 0.1948\, X_{1C} + 0.5999\, X_{1D} \quad \text{Equation 10}$$

SP_2 = $0.0809\ X_{2A} + 0.1244\ X_{2B} + 0.1948\ X_{2C} + 0.5999\ X_{2D}$ Equation 11
SP_3 = $0.0809\ X_{3A} + 0.1244\ X_{3B} + 0.1948\ X_{3C} + 0.5999\ X_{3D}$ Equation 12
SP_4 = $0.0809\ X_{4A} + 0.1244\ X_{4B} + 0.1948\ X_{4C} + 0.5999\ X_{4D}$ Equation 13

G. Model constraints

1- All chosen production scenarios have to be higher than the initial forecasting scenario.
P1, P2, P3, P4, … > P_f Where: - P_f is the initial forecasting scenario.
2- All chosen production scenarios never exceed the process plant design capacity
P1, P2, P3, P4, … ≤ P_p Where: - P_p is the process plant design capacity.
3- All chosen production scenarios never exceed the oil wells erosional velocity
P1, P2, P3, P4, … ≤ P_w Where: - P_w is the oil wells erosional velocity

7. Model Run Test and Results.

As per the data stated before for the case study company; found the following decision variables and constraints

1- The high production rates must be less the oil wells and plant maximum capacity, in this case they will be above nominal 53.3 mbbls/day (forecasting) and less than nominal 66 mbbls/day (plant maximum operation capacity to avoid all operations wastes).
2- The scenarios that can be examined by trial and error according the mentioned proposed oil production decision tree flow chart are nominal 56, 58, 60, 64, 66 mbbls/day.
3- For each mentioned scenario including the forecasting scenario nominal 53.3 mbbls/day and the actual overproduction scenario 90 mbbls/day; the expected or actual oil reservoir life and the total oil recovery along this life will be calculated using pressure decline curve simulation and the daily actual production for the actual overproduction scenario found the following Table 7 and the simulation results shown in the curve in Figure 8

Table 7. Proposed Oil Production scenarios reservoir life and total oil recovery

The production scenario	Number of production year, n	Total oil Recovery, Tr Million bbls
Initial forecast scenario, nominal 53,300 bbls/day	22	151.97
Simulated Nominal 56,000 bbls/day	21	144.52
Simulated Nominal 58,000 bbls/day	20	148.48
Simulated Nominal 60,000 bbls/day	19	149.44
Simulated Nominal 62,000 bbls/day	17	147.10
Simulated Nominal 64,000 bbls/day	16	153.92
Simulated Nominal 66,000 bbls/day	15	150.21

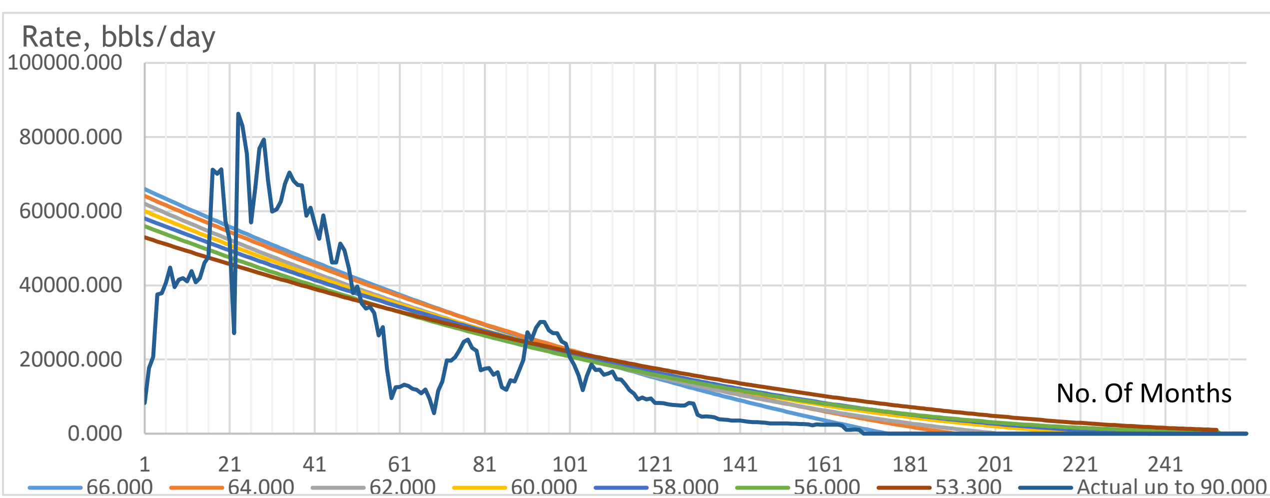


Figure 9. Different oil production rates reservoir life using Pressure Decline curve simulation PDC

4- After calculate the revenue and the monetary value of each scenario as per Table 8

Table 8. Proposed Oil Production scenarios financial issues

The production scenario	Number of production years.	Total oil sales Revenue, B$	Total oil sales Monetary Value, B$
Initial forecast scenario, nominal 53,300 bbls/day	22	12.19	53.98
Simulated Nominal 56,000 bbls/day	21	11.49	52.56
Simulated Nominal 58,000 bbls/day	20	11.86	54.61
Simulated Nominal 60,000 bbls/day	19	11.87	55.25
Simulated Nominal 62,000 bbls/day	17	11.66	55.25
Simulated Nominal 64,000 bbls/day	16	12.18	57.84
Simulated Nominal 66,000 bbls/day	15	11.92	57.60
Actual overproduction scenario up to 90,000 bbls/day	15	9.83	49.54

5- The final scoring and ranking for the production options as per the following Table 9

Table 9. Final Scoring and Ranking for the Production Options

Criterion	AHP weight	Simulated rates "All Nominal", 1000 bbl./day							
		Actual	53.3	56	58	60	62	64	66
TR	0.0809	1.00	4.71	3.60	4.19	4.33	3.98	5.00	4.45
NY	0.1244	1.00	5.00	4.43	3.86	3.29	2.14	1.57	1.00
RV	0.1948	1.00	5.00	3.81	4.44	4.46	4.10	4.98	4.54
MV	0.5999	1.00	3.14	2.46	3.44	3.75	3.75	5.00	4.88
Sum Product		1.00	3.86	3.06	3.75	3.88	3.64	4.57	4.30
RANK			4	7	5	3	6	1	2

6- From the above model and calculations, for the subsea oil company under the study; it has found that the best production option is to produce the oil from the mentioned subsea system with nominal production of 64,000 bbls /day this will achieve the best values of the system which are 16 years of wells life, total oil recovery of 153.92 million bbls., total oil sales revenue of 12.18 B$ and Total oil sales Monetary Value of 57.84 B$ along of the wells life of 16 years.

8. Future Work for Model Sustainability

Most of oil and gas companies tend to overproduce oil and gas above the initial forecasting of the wells due to economic and market pressures and due to some errors coming from the old forecasting methods. The oil overproduction is a big source of the operations wastes for the company assets and future values which decrease the benefits of the overproduction. A new model is proposed to solve the overproduction problems by using lean concepts to concentrate the operations values and rank them with their weights. This proposed model is readily to be used by any oil and gas company need to overproduce its production of oil and gas from the available production options to increase profits and to response correctly to the increased demand and in the same time not to affect its assets or values due to the uncalculated overproduction.

To make the model use sustained; the companies need to carry out the following future work:

1. Install the method and use the model as a recommended practice:
2. Top management and leader's intervention:
3. Model Requirements, Processes & Guides points must be provided in more detailed guidance to the company responsible teams to support them on how to convert the model requirements from plans to execution.
4. Maintain the model and the method by regular routine checks:
5. Competent team organization:
6. Learning loop

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