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Boosting and sustaining the gas and gas condensate production from the Gullfaks Sør subsea satellite field

Experts in Teamwork 2013 Gullfaks Village

Group 4

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Abstract

Statoil wants to utilize a new type of wet gas compressor subsea to enhance recovery and boost the life time of the Gullfaks South field. Today the gas field produces by natural pressure depletion. This report contains a study of the effects of installing the wet gas compressor module on production and economics. The methods used in the evaluation are dry gas material balance and dry gas flow equations. The computer tools used to implement these equations has been Microsoft Excel, VBA and HYSYS. The results clearly state that Statoil should proceed with the installment. The project will have a great impact on both recovery and life span of the field. The recovery factors increase considerably. It is also recommended to proceed with a low pressure modification on the topside separators of the Gullfaks C platform in 2018 which yields a positive NPV of 900.3 MNOK in 2029. Sensitivity analysis shows that the project is robust to changes in economic parameters such as CAPEX, gas price and discount rate. A change in CAPEX will have the largest impact on the value of the project.

Contents

1. Introduction

Gullfaks South is a satellite to the main Gullfaks field and was discovered in 1978 [1]. It is situated in the northern North Sea, figure 1, and includes blocks 34/10 and 33/12. The field is developed with subsea production installations with tiebacks to Gullfaks A and C platforms. Even though it was discovered as early as 1978, it didn't come on stream until 1998. As opposed to the Gullfaks main field, which produces oil, Gullfaks South produces mainly gas and some condensate.

Figure 1: Location of the Gullfaks licence

The reservoirs of the Gullfaks South field are located at depths of 2400-3400 m in rotated fault blocks. The reservoirs are heavily segmented with an abundance of internal faults. The initial reservoir pressure was 450 bar at datum depth of 3300 m below mean sea level. Over the years, the field has been produced by pressure maintenance by gas injection to some extent, but this was discontinued in 2009. Today, the reservoir produces by the means of natural pressure decline. The relevant reservoir for this project is located in the Brent group of middle Jurassic age and has good reservoir properties. The reservoirs in question are produced by two templates, the L- and M-template, and are located approximately 14 km from the Gullfaks C platform. The Gullfaks field layout with its satellites is shown in figure 2 below.

In May 2012 Statoil and partner Petoro decided to invest in the installation of a wet gas compressor on the seabed. The objective of installing the compressor is to boost the gas pressure before transportation in the pipeline and separation on the platform. The compressor will contribute to keeping a plateau production for a longer period. This will result in a longer lifetime of the field thus depleting more of the remaining resources, yielding a higher recovery factor.

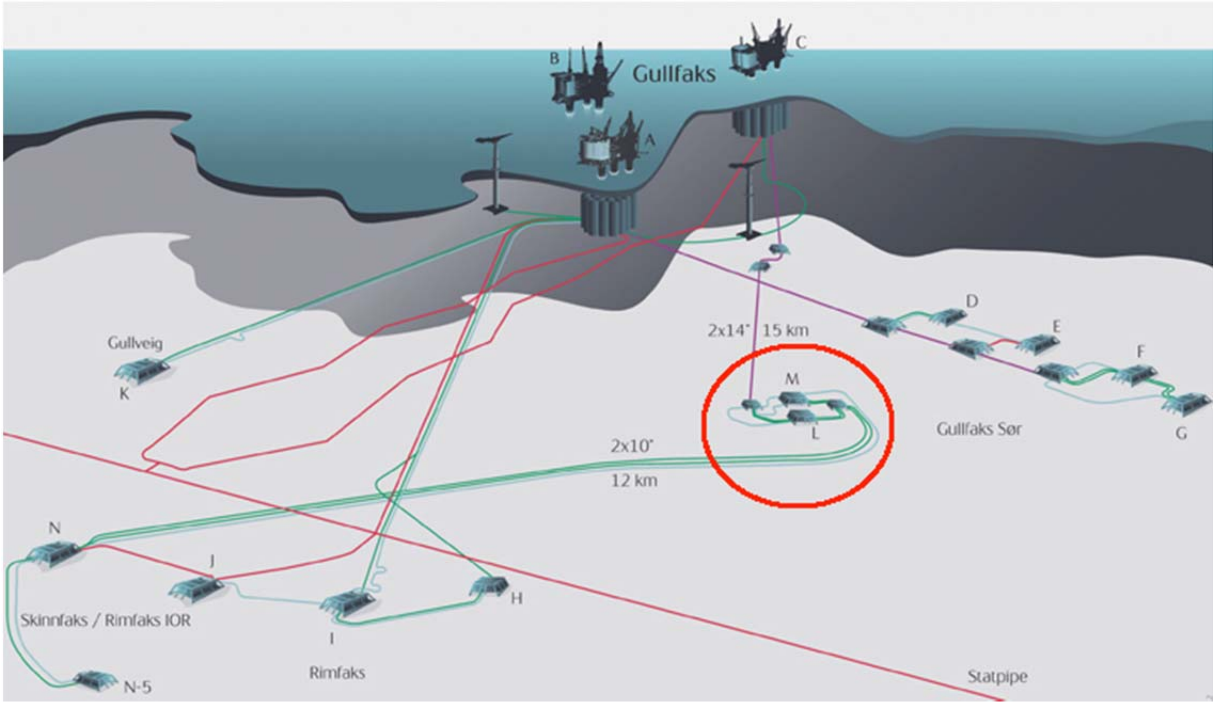

Figure 2: Gullfaks field layout with satellites

The production of the field has been declining for years after reaching a maximum in 2005, as shown in figure 3, while there are still resources left in the reservoir.

The objective of the Gullfaks Village 2013 is to simplify this case from reality and to do production and economic calculations. Statoil wants to see if the village can produce similar results with much simpler tools and methods.

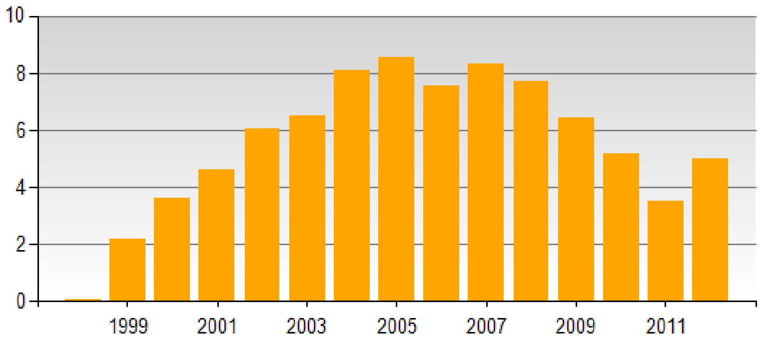

Figure 3: Total production of oil equivalents (MSm3)

2. Gullfaks C subsea wet gas compression

This project is based on a pilot project in development by Statoil and Framo Engineering. Statoil is the operator of the Gullfaks licence and Framo Engineering is the manufacturer of the new compressor module Statoil wants to install. The innovative aspect of this project is the use of a specially designed wet gas compressor module that will be placed subsea. When the field is producing, the pressure in the reservoir will decline. There will be additional pressure loss in the well and pipes that eventually make the pressure too low to enter the first stage of separation. The main issue that the compressor will resolve is keeping the pressure high enough when the gas enters the separator topside.

Today a similar subsea compression system is used on the Åsgard field. This set up includes a separator, one pump and one compressor [2]. The benefit of a WGC subsea compression system is that it excludes the need of a subsea separator and makes the set-up much simpler. This technology is very promising, extending the life time of mature gas fields potentially increasing the recovery factor.

2.1 Design basis and technical specifications

The layout of the production system is shown in figure 4. Template L produces from 4 wells while template M also has 4 wells, but only produces from 3. The reservoir pressures for the L-and M-templates in 2008 were 240 and 210 bara respectively. Over time (at constant flow rates) the pressure potential over the chokes decreases as the reservoir depletes. The target production rates set by Statoil (4 and 6 MSm^3/d) from the L- and M-template cannot be maintained after a certain time. Instead of decreasing the flow rates rapidly because of lack of pressure potential to drive the gas to the topside separator, Statoil wants to add pressure by using the compressor module to maintain the maximum production for a longer period.

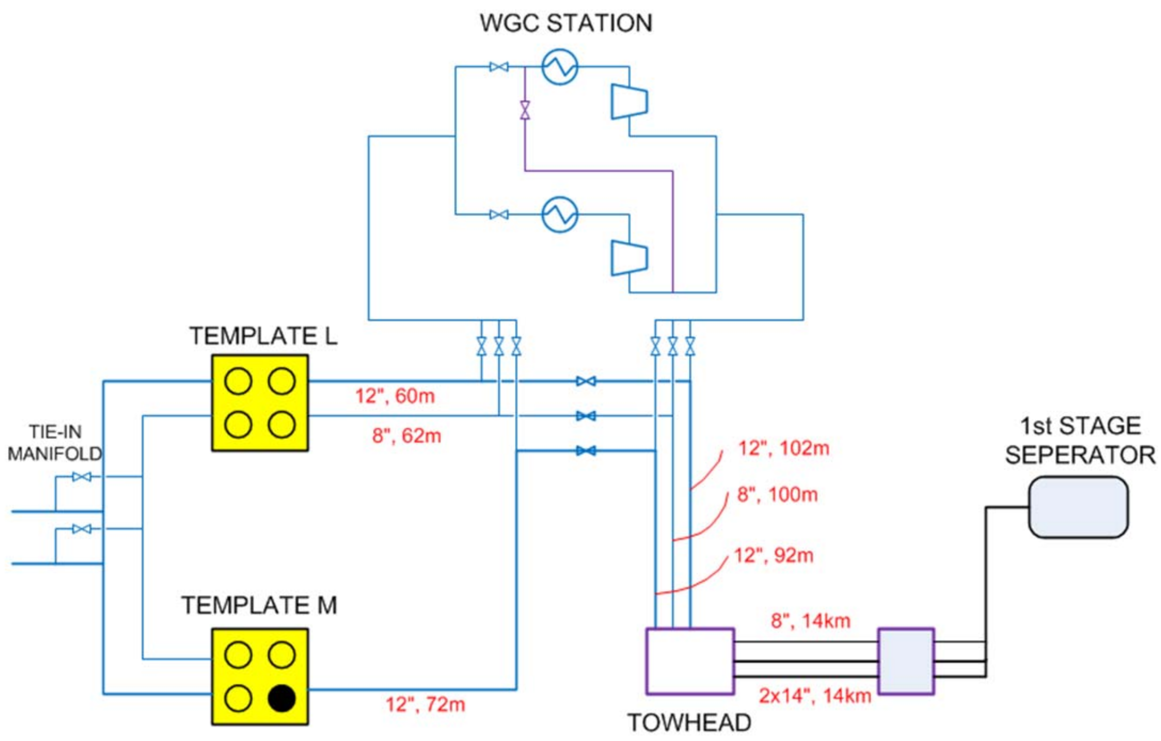

Figure 4: Production layout after installation of compressor

Initially, before the compressor module is installed, the gas flows from the templates in 12'' pipes to a towhead that combines the flows. The gas then travels from the towhead to the separator in two 14'' pipes over a distance of 14 km. After the installation of the compressors, the flows will be diverted to go through the compressor module. There is a valve at the inlet of each compressor. When the compressor is run in parallel, both valves are open. The switch to series compression is done by closing one of the valves and opening the valve on the pipeline that goes between the compressors. There is one passive cooler, using seawater, mounted in front of each compressor.

The compressor module will consist of two 5 MW wet gas counter rotating compressors that can operate either in parallel or in series. The boosting pressure capacity is 32 and 60 bar for parallel and series respectively. The maximum flow rate if running in series is 5 MSm^3/d. Compressor maps and operation specifications are provided by FRAMO.

The reservoirs are modelled as isothermal tanks. Chokes on each well are used to control the flow rates from the L- and M-template such that the pressure in the towhead will be the same from the two templates. There are some options regarding transportation, however only the 12'' pipes from the templates to the towhead are used in the calculations. From the towhead to the separator the gas is transported in equal amounts in two 14'' pipes. A downtime of 10% is assumed in the initial calculations. The height difference in the piping is neglected. The final assumption is the dry gas assumption. All the flow equations and the material balance equation used apply for dry gas only. This implies that some of the extra pressure drop that would occur for gas condensate is neglected. These assumptions are made to assess if Statoil could have used easier and simpler methods for the studies concerning the subsea wet gas compression project.

2.1 Method of execution

2.1.1 Gas production calculations

The main tool used to perform the calculations is Microsoft Excel with use of VBA (Visual Basics for Applications) programming. Aspen HYSYS was also used to generate black oil tables to calculate condensate production.

The reservoir production is calculated using a simple material balance equation given by:

$$P_R = P_i \left(\frac{z_R}{z_i} \right) \left(1 - \frac{G_p}{G} \right) \tag{1}$$

where P_R is the reservoir pressure for the following year (i+1), and P_i is the reservoir pressure current year (i). The z-factors are the compressibility factors accounting for the non-ideal gas behaviour. z_R is the compressibility factor at the reservoir conditions in year (i+1) and z_i is the compressibility factor in year (i). G_p is the cumulative gas production, and G is the gas initially in place. The term G_p/G is the recovery factor.

The well bottom hole flowing pressure, P_{wf}, is calculated by the "inflow" equation:

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

where q_{gsc} is the well flow rate, C_R is the inflow back pressure coefficient and *n* is the backpressure exponent.

The pressure at the wellhead, P_{wh} is calculated from the pressure drop in the tubing. The tubing equation used is:

$$q_{gsc} = C_T\left(\frac{P_{in}^2}{e^s} - P_{out}^2\right)^{0.5} \tag{3}$$

where C_T is the tubing coefficient for a 7'' tube with an inner diameter of 6.094''. P_{out} will be P_{wh} and P_{in} will be P_{wf}. The exponent of 0.5 applies for turbulent flow. S is the elevation coefficient. This is given as 0.43 and 0.34 for the L- and M-template respectively.

The pressure in the separator is 65 bara, thus the pressure required in the towhead can be back calculated using the horizontal flow line equation (eq. 4). In reality there is a height difference of about 178 m which is not taken into account using this equation. The pressure in the template is then back calculated from the towhead.

$$q_{gsc} = C_{FL}\left(P_{in}^2 - P_{out}^2\right)^{0.5} \tag{4}$$

where C_{FL} is the flow line coefficient.

The equation used for the compressibility factor is based on the Hall & Yarborough equation fitted to Standing-Katz Chart (eq. 5) [3].

$$z = \frac{0.06125 P_{pr} t e^{-1.2(1-t)^2}}{y} \tag{5}$$

Where $t=T_c/T$, the critical temperature divided by the reservoir temperature, and y is the reduced density which is the solution of:

$$y = -0.06125 P_{pr} t e^{-1.2(1-t)^2} + \frac{y + y^2 + y^3 - y^4}{(1-y)^3} - \left(14.76t - 9.76t^2 + 4.58t^3\right) y^2$$
$$-\left(90.7t - 242.2t^2 + 42.4t^3\right) y^{(2.18+2.82t)} = 0 \quad (6)$$

The basic data obtained from Statoil needed to do the calculations is given in Appendix A.

After the chokes on each well are fully opened, the pressure in the towhead from both templates must be the same. To achieve this, an error column for the pressure difference in the towhead from the L- and M-template is made. The flow rates from the two templates are adjusted using the solver in excel to minimize the error in the error column. After the installation of the WGC, another column for the compression ratio and the compression pressure is made. Again the solver is used to optimize the production by maximizing the pressure differential over the compressor according to the specifications given by FRAMO.

2.1.2 Condensate production and validation of dry gas assumption

In order to calculate the condensate production, black oil tables are generated in HYSYS in order to find the oil in gas ratio. These tables are also used in an in-house software called IPT-MATBAL. This program is based on a material balance [4], calculating the real reservoir pressure and real gas condensate (GC) production. These results are compared to the reservoir pressure and condensate production calculated from the dry gas (DG) material balance (figure 5).

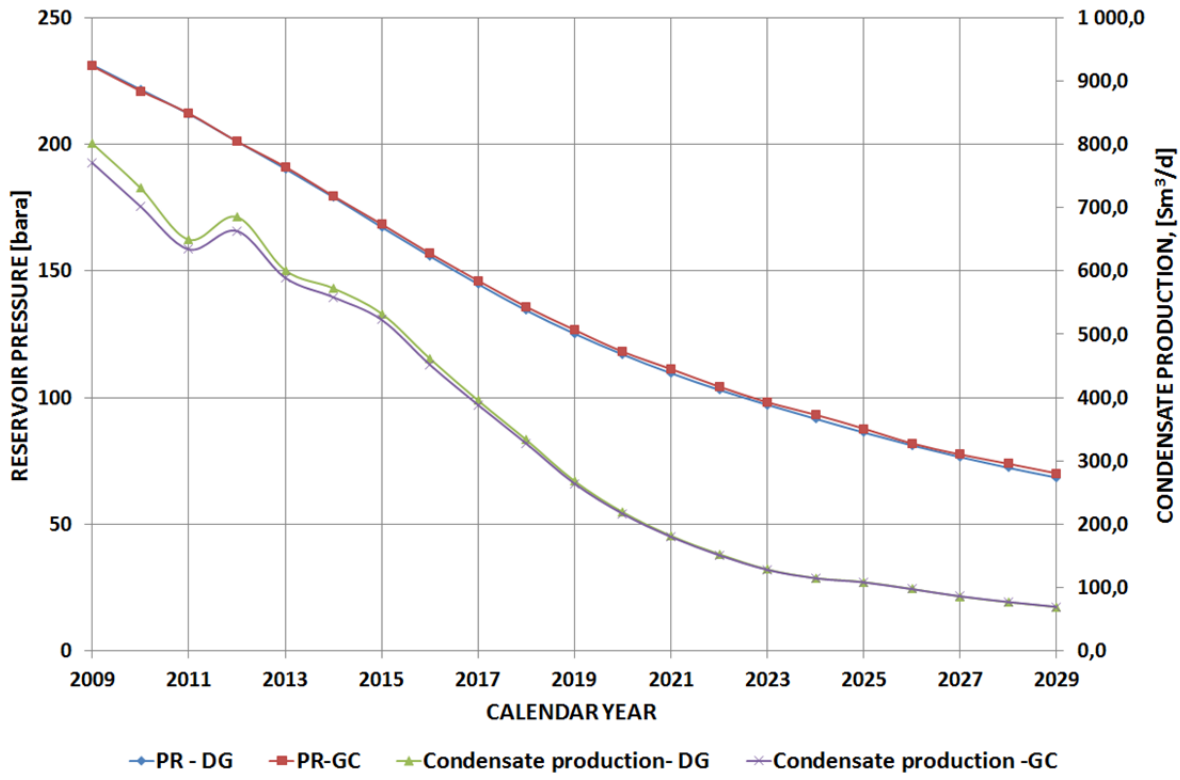

Figure 5:Reservor pressure and condensate production comparison

It is clear from the figure that the dry gas assumption is a valid assumption since the discrepancy between reservoir pressures and condensate productions are acceptably small.

2.2 Cases studied

The project is divided into two main aspects, production and economics, where each aspect is divided into subsea compressor case (WGC), subsea compressor case with 15% downtime (WGC 15% downtime) and subsea compressor case with low pressure modification from 2018 (WGC + LP2018). The objective is to compare these three cases with a reference case, without subsea compressor, both in terms of production development and economic impact.

The subsea compressor case involves installing the compressor when required. For the second case, subsea compressor with 15% downtime, the downtime is increased from 10% to 15%. This is to be expected when installing brand new equipment, which is bound to have some issues in the beginning. The last case, a low pressure modification, is an additional attempt to increase the recovery from the field. This involves doing modifications topside on the platform to reduce the pressure in the first separator from 65 to 25 bara.

The economic analysis is carried out according to the Norwegian Ministry of Finance taxation rules of petroleum activities [5]. According to Statoil the subsea WGC will cost an estimated 3000MNOK while the LP conversion will incur an additional cost of about 1000 MNOK [6]. The contractors of the subsea WGC project are FRAMO Engineering, Nexans, Subsea 7 and Apply Sørco. Table 1 shows the main contracts and contractors for the subsea WGC project.

Table 1: Contracts related to the Gullfaks subsea WGC project [7-10]

Contractor		Worth
Framo Engineering	WGC design, testing and construction	900 MNOK
Nexans	Umbilical	70 MUSD
Subsea 7	Engineering services and equipment	16 MEUR
Apply Sørco	Installation, upgrading and service	375 MNOK
	Total	1800 MNOK

In order to calculate the worth added by the WGC project a reference case is made until 2029. From this reference case the incremental gas and condensate sales volumes, of the respective cases, are calculated. A gas price of 2.3 NOK/Sm^3 and an oil price of 110 USD/bbl are used in the calculations. Tariffs for oil and gas are not included in the economic calculations. The operating expenditures (OPEX) are obtained from Statoil (Baard Haugse). These values include CO_2 and NO_X taxes and also the loss in sales volume of gas which is burned off in a gas turbine which generates power for the compressors. Every 3rd year the OPEX is higher due to maintenance and the ordinary revision-stop. It is important to emphasize that the OPEX values used are not the total operating cost for the Gullfaks C platform, but the increase in OPEX due to the subsea WGC installation.

The investment distribution used in the calculations is n-2: 20 %, n-1: 40 % and n: 40 %, where n represents the year of installation of the subsea WGC. The total capital expenditure (CAPEX) is depreciated linearly over 6 years according to the depreciation rules of petroleum activities. However, the sales incomes are subtracted for OPEX. Depreciation and losses carried forward yielding the ordinary tax base which is taxed at 28%. The uplift is 7.5 % of the cost price of the depreciable operating assets. The uplift is subtracted from the ordinary tax base, yielding the special tax base which is taxed at 50 %. The gross profit and cash flows of every calendar year are calculated. Eventually the present values, and net present values (NPVs) are obtained. The discount rate (cost of capital) is set to 8 %, and inflation is neglected.

2.2 Production Results

2.2.1 The Reference case:

The target gas production rate is 10 MSm^3/d , and the initial configuration is that template L produces 6 MSm^3/d while the M-template produces 4 MSm^3/d . Each well produces the same amount. The objective is to maintain the plateau production rate as long as possible by gradually opening the chokes. As long as there is enough available pressure to meet the required pressure, the chokes will be adjusted to get the desired production rate. As the pressure declines, the chokes will be gradually opened until they are fully open. When the chokes are fully open, and the available pressure is equal to the required pressure, production by natural decline is no longer possible if the goal is to maintain a production of 10 MSm^3/d. The rate configuration of 6 and 4 MSm^3/d can continue for some years, but eventually the M-reservoir, which is smaller than the L-reservoir can no longer sustain the 4 MSm^3/d rate. This is illustrated in figure 6 and 7.

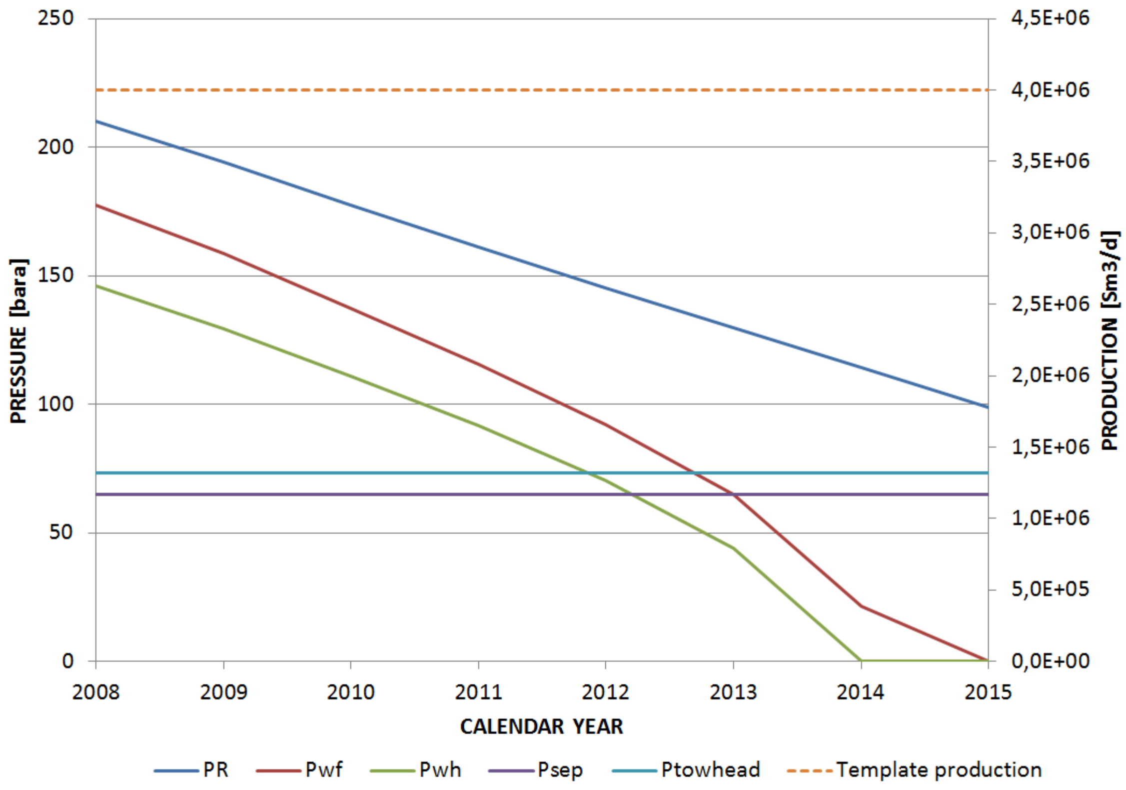

Figure 6: Pressure development for the M-template at the target production rate

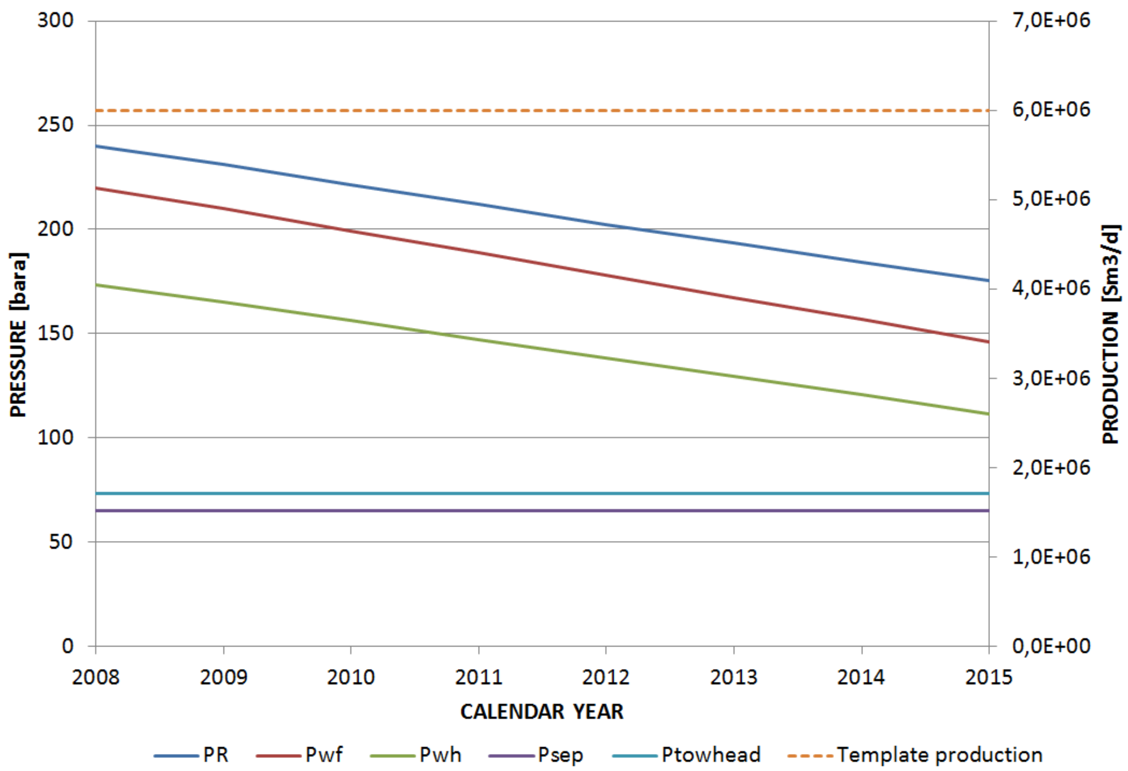

Figure 7: Pressure development for the L-template at the target production rate

Since there is still potential energy left in the L-template reservoir when the M-template reservoir shuts down, there is an option of trying to manipulate the rates from each template so that the plateau production can continue for longer such that the reservoirs stop producing naturally at the same time. By increasing the rate from the L-template from 2013 and simultaneously decreasing the rate from the M-template, the plateau production can be maintained until the middle of 2016. It is assumed that installment of the compressor will make it possible to maintain a production of 10 MSm^3/d for a longer time. Therefore, the compressor should be installed well before the limit is reached with natural depletion.

All the cases are based on a time frame of production until 2029. At the end of 2029, the production rate is down to 1.64 MSm^3/d. This is probably under the economic limit of the field, and there even might be liquid accumulation. However the reference case is done until 2029 for comparison. The cumulative production of gas will be 44.4 billion Sm^3 with recovery factors of 0.62 and 0.63 respectively for L- and M-templates in 2029.

2.2.2 Subsea WGC case

In the calculations the WGC starts operating in 2016 (one assume no stop in production during the installation of the WGC module). This will prolong the 10 MSm^3/d production rate until the middle of 2018. Without the compressors, this limit would have been roughly two years earlier according to the reference case (Appendix B).

From 2016 the compressors run in parallel with a pressure difference from the suction side and the discharge side of 5.54 bara. For 2017 this pressure difference increases to 20.59 bara. This implies that the compressors run under more severe conditions in 2017 to sustain a production of 10 MSm^3/d. This is illustrated in the compressor maps in Appendix C which shows the operating point of the compressors for the different years in a compressor map. The compressors reach their maximum load for a production of 10 MSm^3/d in the middle 2016 (The operating point move to the boundary of the compressor map).

In 2018 the production rate of 10 MSm^3/d can no longer be maintained. The production rate is decreased to 9.59 MSm^3/d. The total production is reduced in the following years until the middle of 2024 where the rate is 5.0 MSm^3/d. The suction pressure (towhead pressure) is reduced from 41.97 bara (2018.6) to 37.12 bara (2024.5).

After the production is reduced to 5 MSm^3/d the option of running the compressors in series become feasible. This makes it possible to maintain the 5 MSm^3/d production rate until the first quarter of 2026. The production development after this point will decline to 3.47 MSm^3/d in 2029. FRAMO claims to have tested the compressors down to a suction pressure of 13 bara. However the minimum suction pressure used in the calculations is 20 bara.

In 2029 the cumulative production for the L- and M-template is estimated to 38.7 billion Sm3 and 13.9 billion Sm^3 respectively. This yields a recovery factor of 0.71 for the L-template and 0.79 for the M-template. The pressure profiles for the L- and M-template are illustrated in figure 8 and 9.

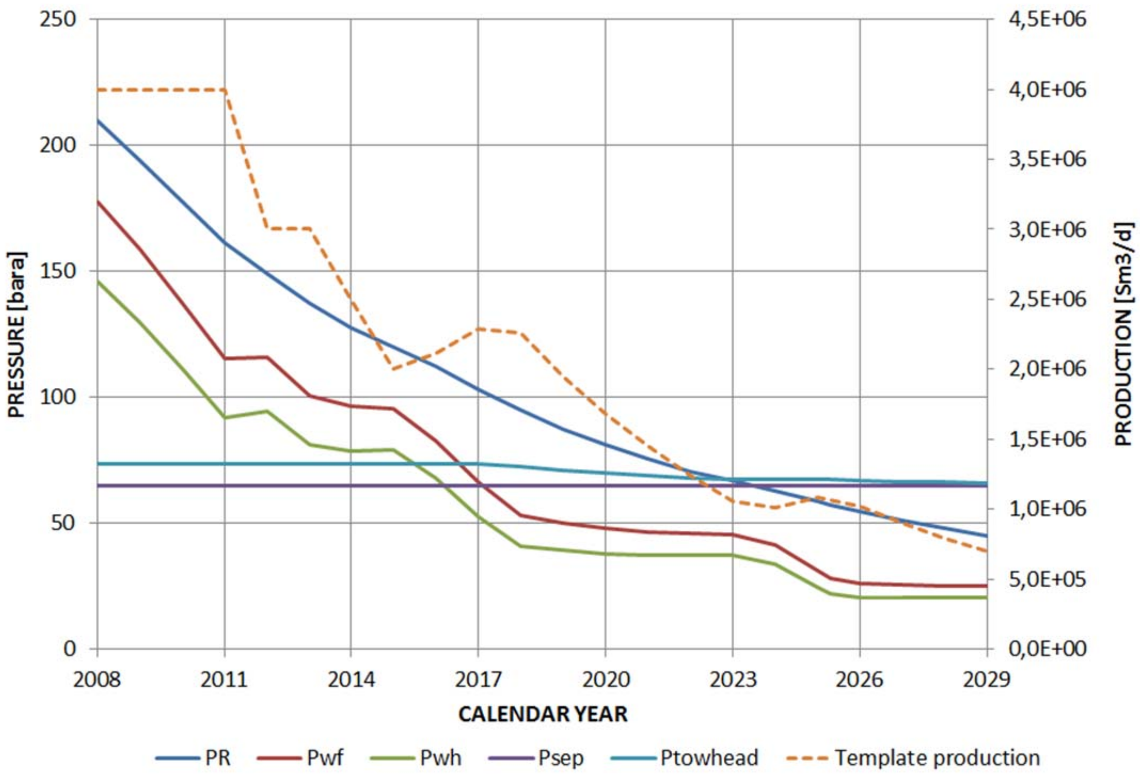

Figure 8: Pressure development for the M-template with manipulated production rates and WGC installed

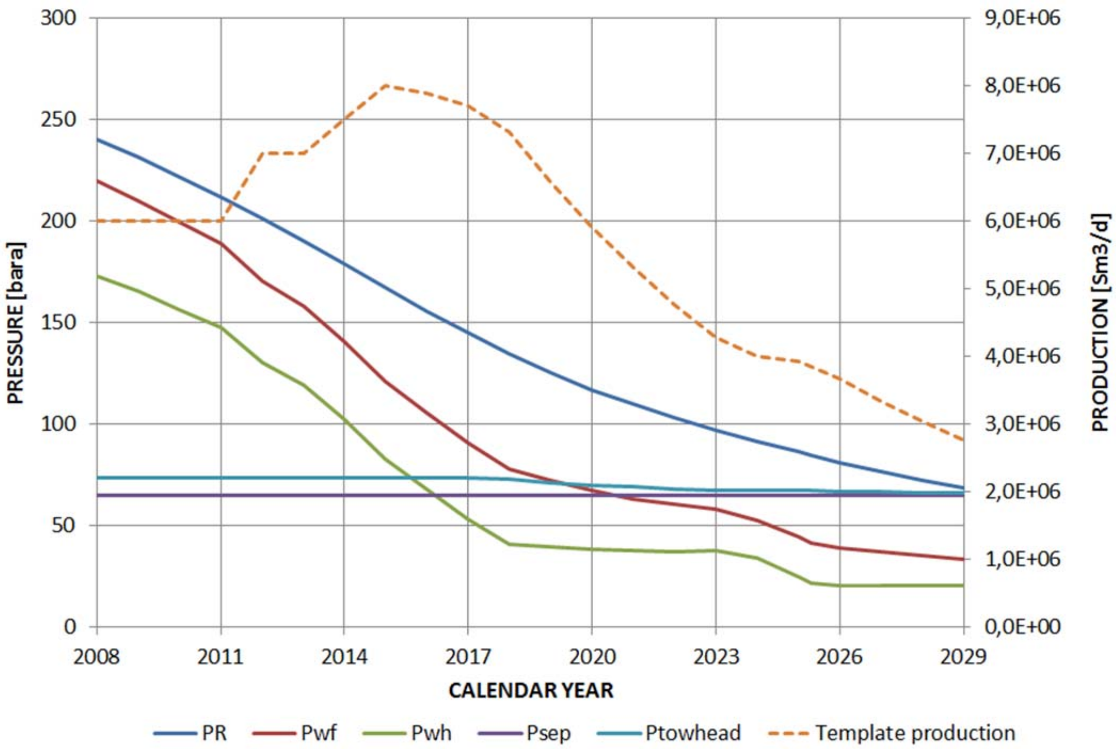

Figure 9: Pressure development for the L-template with manipulated production rates and WGC installed

2.2.3 Subsea WGC with downtime increased

If the downtime increases from 10 % to 15 % the operating days for the L and M will be 309 and 311 days respectively. Due to less production days, the production will be reduced. The production of 10.0 MSm^3/d will be endured until 2019.8 and the 5.0MSm^3/d limit will be reached in 2025. The accumulative production in 2029 will be 51.7 billion Sm^3. This results in recovery factors of 0.70 for L and 0.78 for the M-template.

2.2.4 Low pressure configuration

The low pressure modification is done in addition to the compressor. The lower pressure in the separator allows the 10 million Sm^3/d production plateau to continue for another six months compared to the WGC case. The production rate declines until 2029, and the total production rate is 3.18 million Sm^3/d. The cumulative production is 53.35 billion Sm^3 and the recovery factors are 0.72 and 0.81 for L and M respectively.

2.2.5 Production and recovery

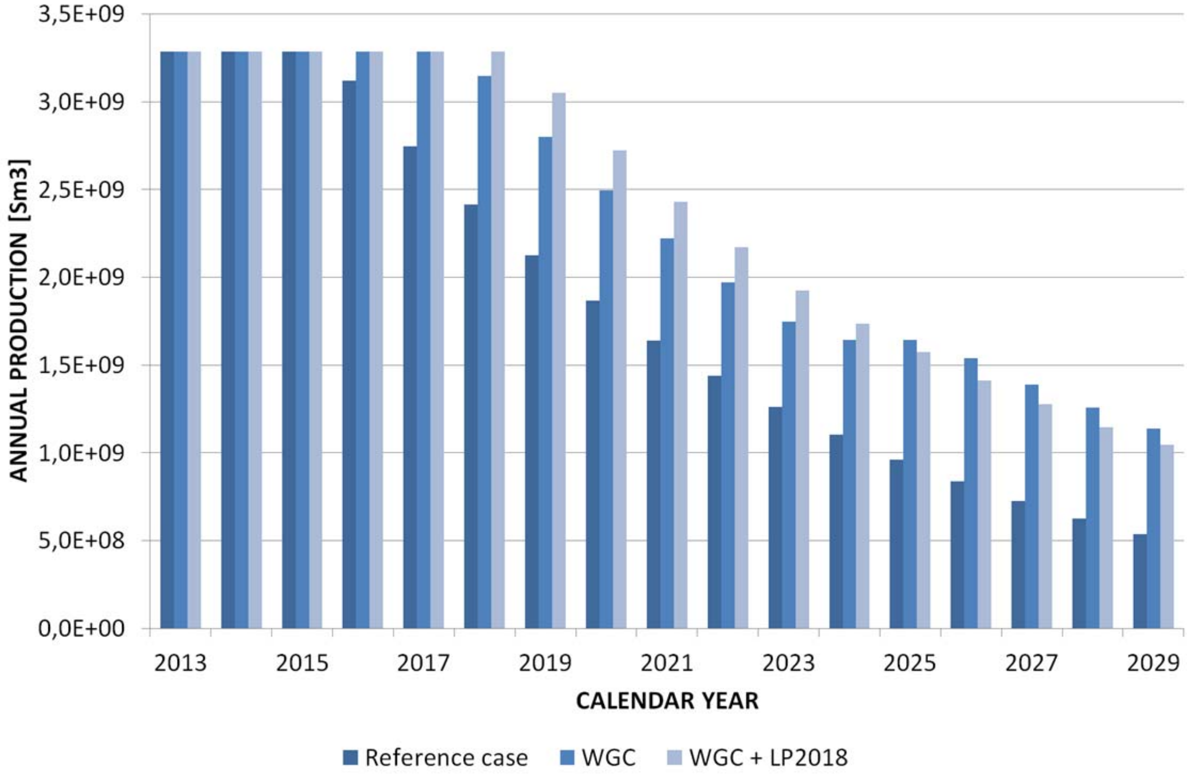

Figure 10: Annual production for the reference case, the WGC and the WGC + LP2018

In figure 10 the annual production for all the cases are compared. Table 2 gives a summary of the main results from the calculations in Appendix B.

Table 2: Summary of the main results in terms of production rates, accumulative production and recovery factors

Situation	CASE	YEAR	Total q_f (million Sm^3/d)	Total G_p (billion Sm^3)	G_p/G (L-Template)	G_p/G (M-Template)
End of 10 MSm^3/d natural plateau	All cases	**2016.5**	**10**	**24.65**	**0.31**	**0.44**
End of 10 MSm^3/d compressor plateau	Reference case	**-**				
	With compressor	**2017.6**	**10**	**31.5**	**0.41**	**0.53**
	Compressor+15% downtime	**2017.8**	**10**	**31.9**	**0.41**	**0.54**
	Low pressure modification	**2019.1**	**10**	**33.19**	**0.43**	**0.56**
5 million Sm^3 Economic limit	Reference case	**-**				
	*With compressor	**2025.3**	**5**	**47.7**	**0.644**	**0.735**
	*Compressor+15% downtime	**2025.6**	**5**	**47.2**	**0.636**	**0.729**
	Low pressure modification	**2025.5**	**5**	**47.71**	**0.64**	**0.75**
Continue production until 2029	Reference case	**2029**	**1.64**	**44.4**	**0.62**	**0.63**
	With compressor	**2029**	**3.47**	**52.6**	**0.71**	**0.79**
	Compressor+15% downtime	**2029**	**3.73**	**51.7**	**0.70**	**0.78**
	Low pressure modification	**2029**	**3.18**	**53.35**	**0.72**	**0.81**

*Series operation of compressor used.

The production rates and recovery factors for every calendar year are displayed in figure 11 and 12 for the M- and L-template respectively.

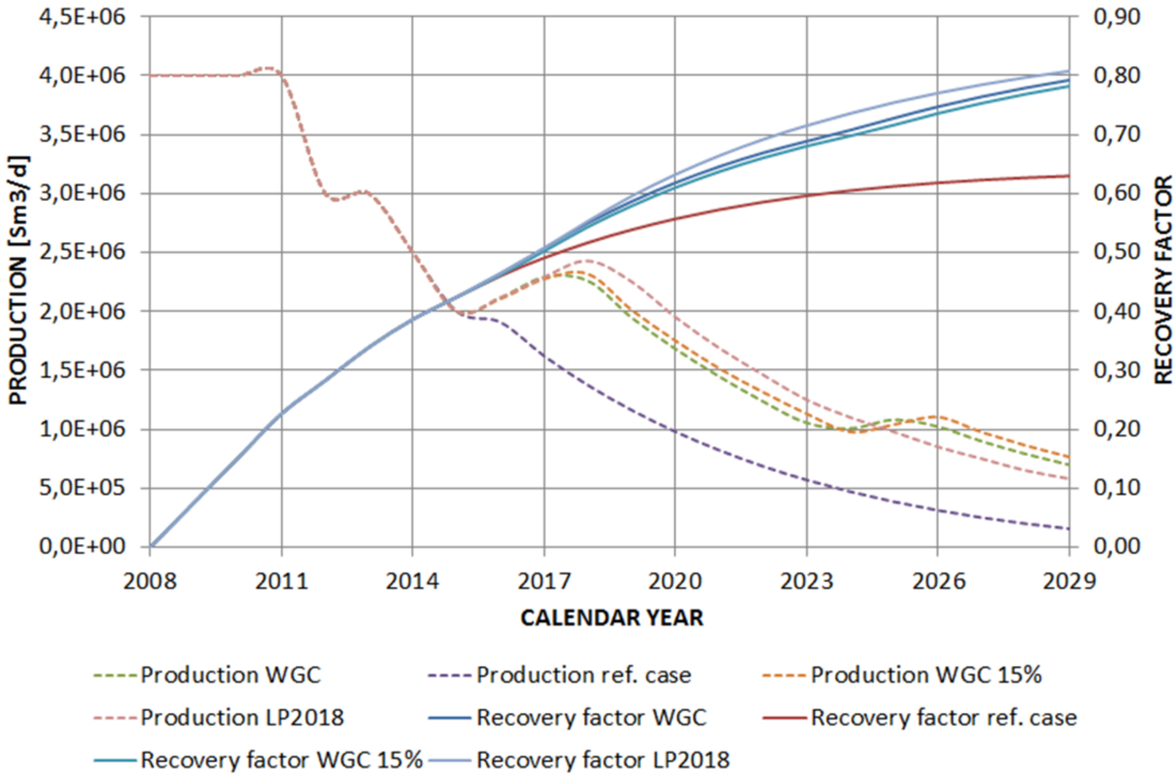

Figure 11: Production rates and recovery factors for the M-template for all cases

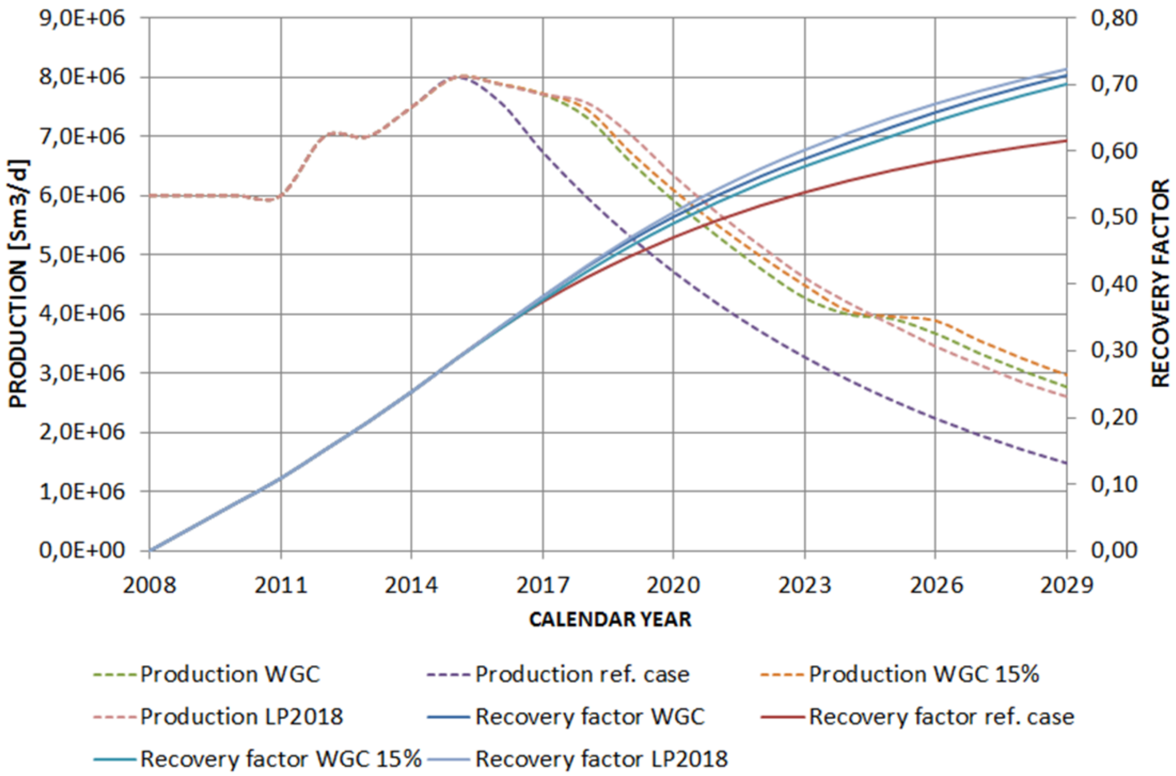

Figure 12: Production rates and recovery factors for the L-template for all cases

2.2.7 Condensate production

Associated with the gas production there will also be a production of condensate. The relation between condensate production and reservoir pressure is illustrated in figure 13 for the WGC case.

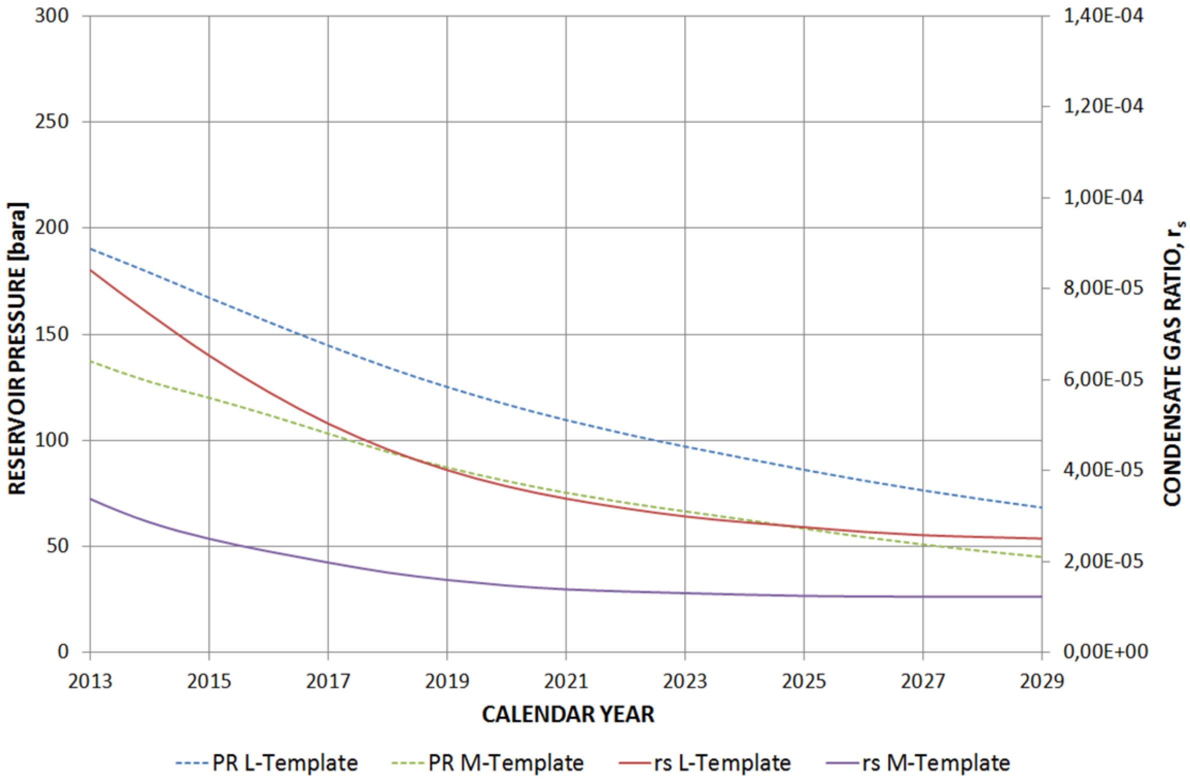

Figure 13: Development in reservoir pressure and condensate gas ratio for the L- and M-template

The condensate production relative to the gas production is given in figure 14. The condensate production is much lower than the gas production. However the condensate production is still valuable and will be evaluated in the economic part.

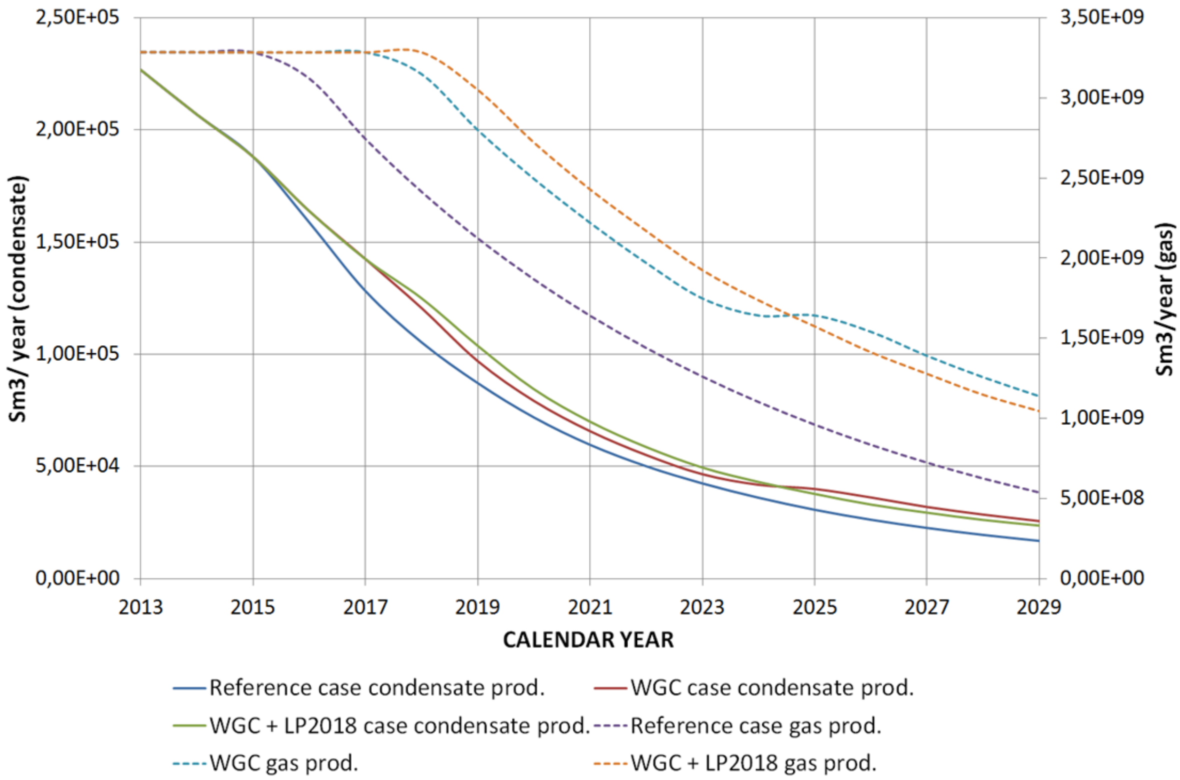

Figure 14: Total annular condensate and gas production for the different cases

2.2.6 Discussion

The production summary table gives the data for the most important milestones for the field. It is apparent that the LP case is the most beneficial project in terms of recovery. This applies both for the 5 MSm³/d limit and for production until 2029. This is to be expected, since the pressure required by the separator is much lower. Because of this low pressure, it is not necessary to run the compressor in series. Therefore, no effort is made trying to keep a second plateau of 5.0 MSm³/d (as was done for the WGC case). This becomes evident in figure 10, where initially the yearly cumulative production for the low pressure case is higher than for the WGC case. A switch happens around 2025, when the WGC case starts to operate in series to maintain the plateau. The LP-case production continues to decrease evenly. Despite this, the total production is still higher for the LP case, due to the higher production in the early stages.

When the downtime increases from 10 to 15%, it basically means that the production is postponed, and it is less compared to the WGC case. From table 2, the recovery for the increased downtime case actually is bigger than for the regular case when the first plateau ends. This is because the end of the compressor plateau is delayed, due to lower production. This effect starts to diminish over time, as seen at the end of the 5 MSm^3/d limit, where the recovery for the regular case is higher than the downtime case, even though it ends earlier. Figures 11 and12 give a clear picture of the recoveries for the different cases as well as production rate. Even though this result states clearly that the low pressure modification gives the highest recovery, it is important to evaluate the economic aspect of the case which includes an extra investment. One should not make these decisions based on production data alone.

2.3 Economic results

2.3.1 NPV and cash flow

An increase in downtime to 15 % (after WGC installation) will make the project less profitable. The NPV for a time horizon of 2029 is reduced from 859.5 MNOK to 596.8 MNOK (Appendix E). Actually, an increase in downtime due to the subsea WGC would decrease the total production for the first year after installation, compared to just continuing with normal production without the compressor. However these losses in production for 2016 can be carried forward yielding a lower tax base the following year. The cash flows generated by the sales volume of gas and the sales volume of oil (condensate), are given for all the cases in Appendix E. Table 3 displays the effect of an increase in downtime to 15 %. The effect in terms of NPV for a 15 year time horizon is 265.4 MNOK, and this difference will get higher for a longer time span.

Table 3: Key economic numbers

	IRR			**NPV (MNOK)**			**Break-even gas price (NOK/Sm^3)**		
Year/case	WGC	WGC 15%	WGC + LP2018	WGC	WGC 15%	WGC + LP2018	WGC	WGC 15%	WGC + LP2018
2023	9.6%	7.4%	10.4%	168.0	-63.9	279.7	2.01	2.43	1.91
2026	12.3%	10.2%	12.7%	553.9	284.3	647.3	1.56	1.85	1.57
2029	13.7%	12.0%	13.8%	859.5	596.8	900.3	1.32	1.52	1.40

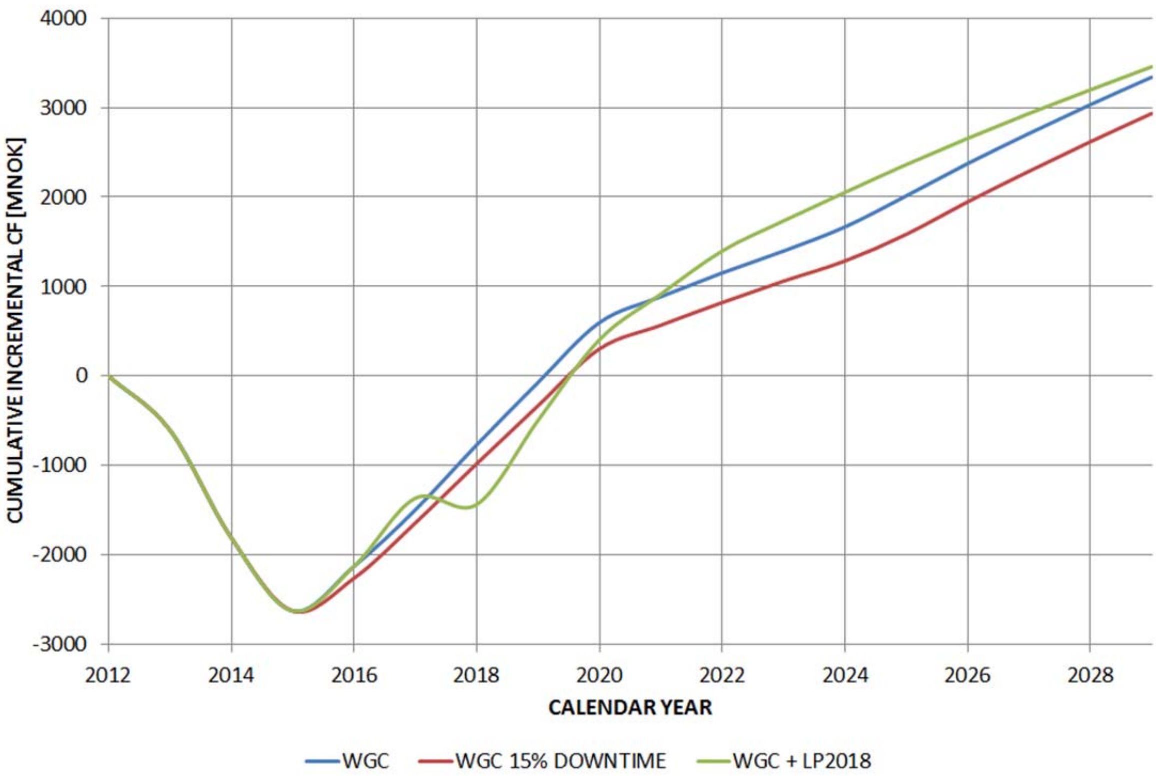

Figure 15: Cumulative cash flow diagram for the WGC, WGC 15% and WGC + LP2018

Figure 15 indicates that both cases will break even around 2019. Under a low pressure conversion of the topside, the production has to be stopped for a short period of time. The stop in production will probably last for a few weeks. However, by increasing the production rate immediately after the stop, the lost production is assumed to be regained.

The LP conversion is favorable, generating a NPV of 900.3 MNOK for a time horizon until 2029 compared to a NPV of 859.5 MNOK without the LP conversion. The drop at 2018 for the LP conversion case is caused by the new investment of 1000 MNOK (affiliated with the conversion.) Some key values as the internal rate of return and NPV are given in table 3.

2.3.2 Discussion

The economic result supports the WGC + LP2018 case. Probably, this option will be even more beneficial compared to the WGC case since the compressor is operating at a maximum for an extended period. More severe operating conditions may cause more wear on the compressor which will have an economic impact on the project. After 2021 the LP2018 becomes the most profitable, as seen in figure 15, where the green line crosses the blue line. The most important factor to determine the real NPV will be the lifetime of the field. In addition, after a certain number of years, the incremental production rate will probably be the total production. This is because the field has to shut down a lot earlier if no project is carried out. The real NPV value may be greater than the values calculated in this project.

2.4 Sensitivity analysis

In this section, attempts are made to predict how the project will be affected by changes in certain economic parameters. Here, three economic parameters, namely; CAPEX, gas price, and cost of capital, are considered. This sensitivity analysis is carried out only for the WGC case without increase in downtime. The target is to give STATOIL options in making decisions on how to invest based on the effects of changes in the aforementioned parameters on the NPV. This analysis is important as it enables one to find the factor that will have the biggest impact on the project and the effects of the best and worst case for NPV. In this light, sensitivity analyses is carried out for +/- 30% CAPEX, +/-9% NOK/Sm^3 gas price, and +/-25% cost of capital on NPV over the entire period of production until 2029.

(i) Effect on NPV +/- 30% change in CAPEX

From figure 16, it is concluded in all the cases the NPV's are sensitive due to change of CAPEX. This project can break-even in 2020 if the CAPEX is 30% less. On the other hand, the company has to wait until 2024 to make profit if the investment is 30% higher than the initial case. At the end of the year 2029, the NPVs are 1180, 859 and 538 MNOK for -30% CAPEX, initial CAPEX and +30% CAPEX respectively.

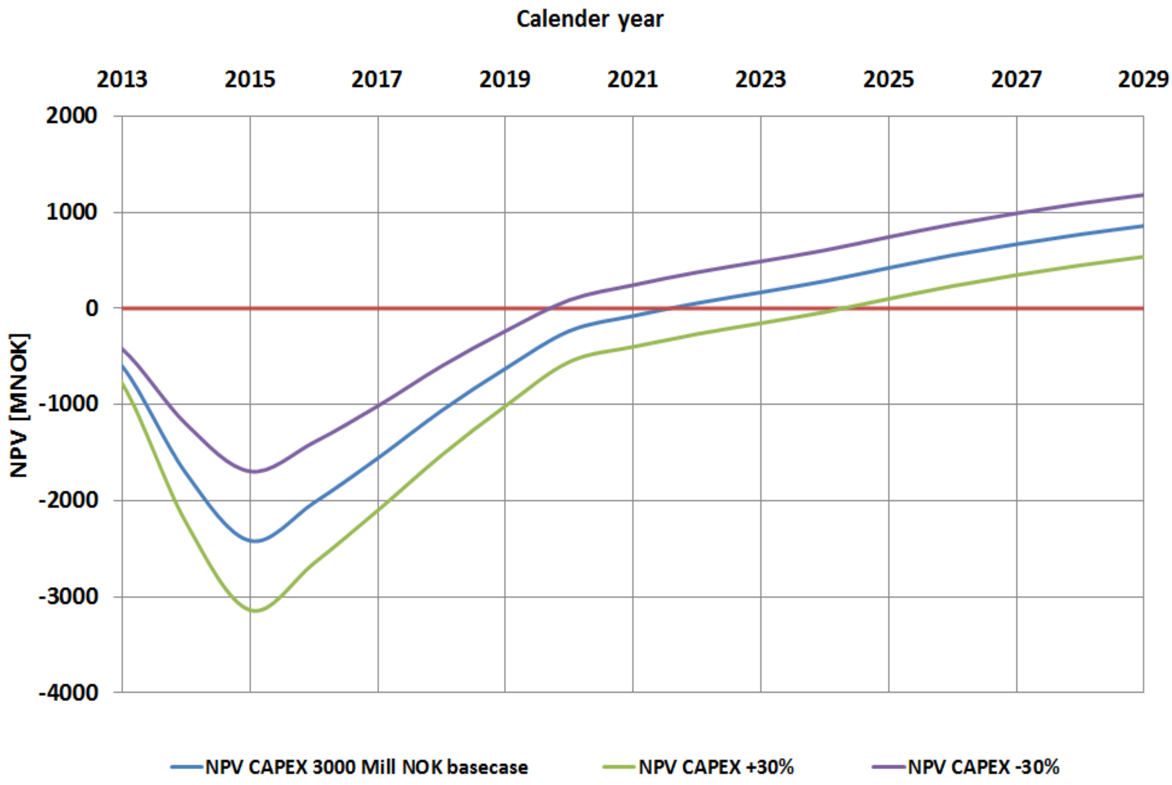

Figure 16: Effect on NPV by change in CAPEX

(ii) Effect of change of NPV in gas price

In figure 17 the effect of changes in gas price on NPV is displayed. The project is not very sensitive by changes in gas price. The profit has slightly increasing trend from the year 2023 till 2029. However, 2.5 NOK/Sm^3 gas price is the favorable situation when the profit is the major concern. At the end of 2029 the NPVs are 1035, 860 and 684 MNOK for 2.5 NOK/Sm^3, 2.3 NOK/Sm^3 and 2.1 NOK/Sm^3 respectively.

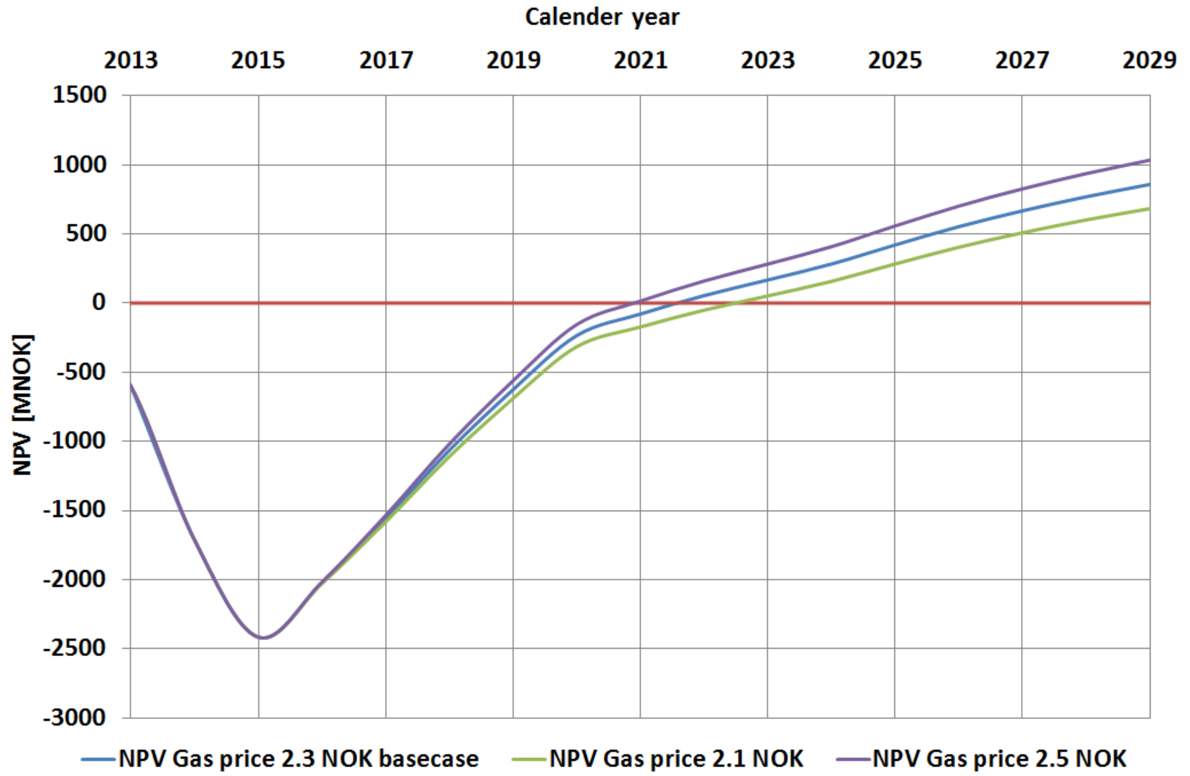

Figure 17: Effect on NPV by change in gas price

(iii) Effect of change of cost of capital on NPV

In figure 18, one can see the variation in NPV by changing discount rate. The best way to earn more money is to reduce discount rate by 25%. At 8% discount rate, the project starts to yield profit in 2022. However, the project is still economically feasible in case of 25% increment in discount rate. It only delays the payback time for another three years, compared to that of reduction in cost of capital. The NPV's are 1294, 860 and 505 MNOK for -25%, initial discount rate and +25% discount rate respectively at the end of year 2029. The details of the total cash flow is shown table 4.

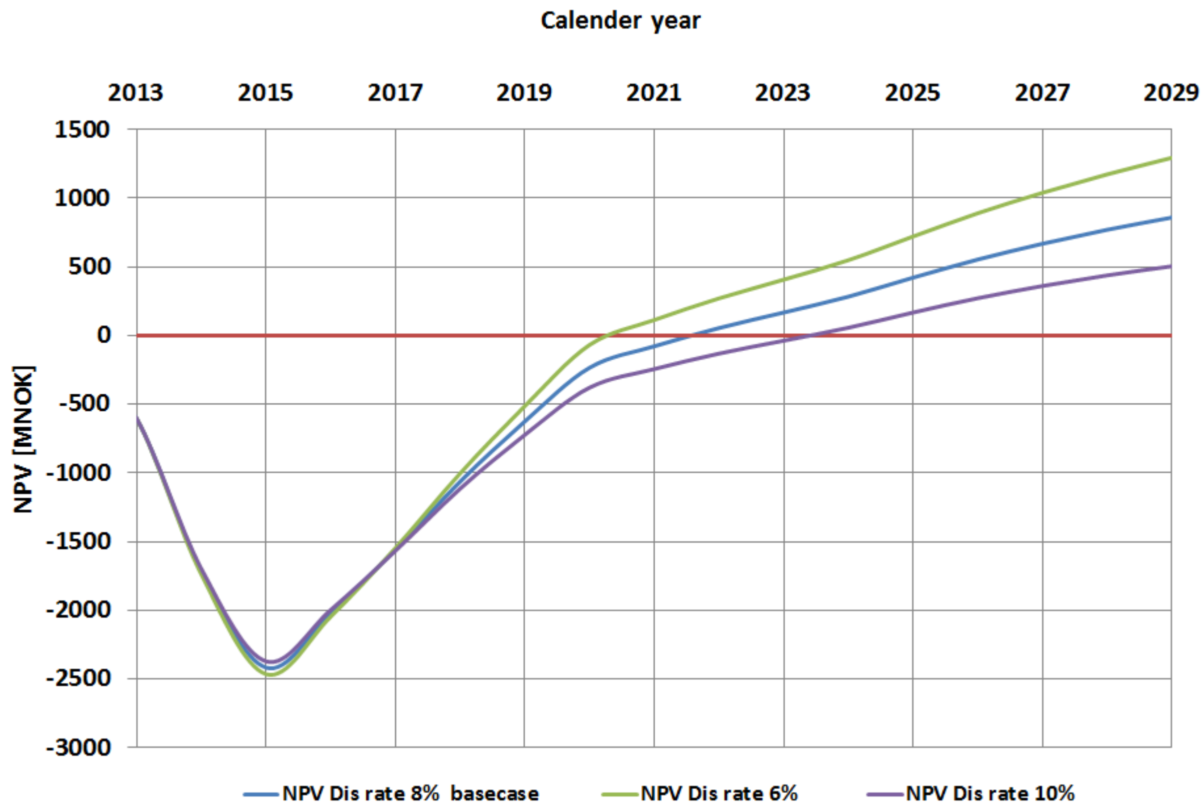

Figure 18: Effect on NPV by change in discount rate

Figure 19 represents a spider diagram of the NPV sensitivities. The three economic parameters are used to compare NPV at the end of year 2029. More profit can be obtained by using WGC+LP modification. After that, it can be underlined that the LP conversion is the best case to make profit followed by WGC and WGC 15% downtime in that order. The NPV decreases as the lines move towards the center of the figure.

Table 4: NPVs in MNOK 2029

Cases	CAPEX (-30%)	CAPEX (+30%)	Gas Price (-9%)	Gas Price (+9%)	DR (-25%)	DR (+25%)
WGC 10% downtime	1180.6	538.3	684.1	1034.8	1294.3	504.7
WGC 15% downtime	917.9	275.6	443.7	749.8	1003.4	266.5
WGC + LP conversion	1221.5	579.2	701.0	1099.7	1351.7	531

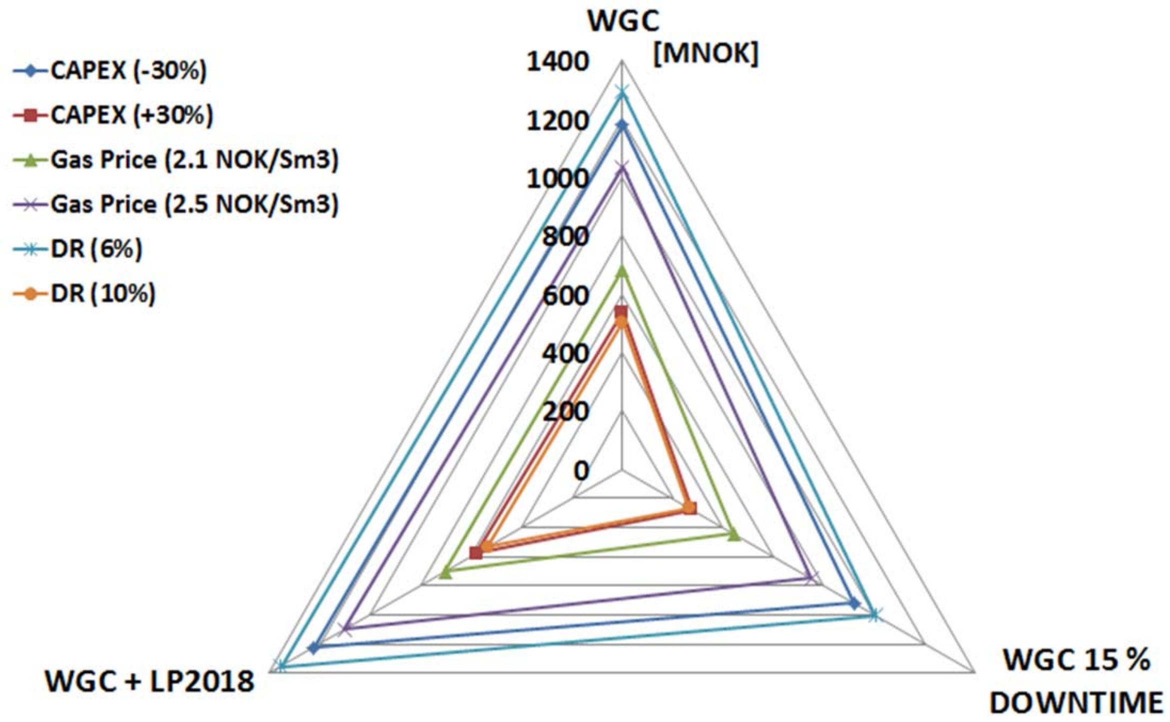

Figure 19: Spider diagram of the different sensitivity parameters

2.4.1 Tornado Diagram

Another way to present sensitivity analysis is the "Tornado Chart", as shown in figures 20-22. The centerline for all the tornado charts is representing the NPV of the base case in 2029 and the red part of the bar represents a lower NPV compared to the base case. The length of the bars represents how sensitive the projects are for the given parameters. The shorter bars for the gas price implies that the project is not the most sensitive to a change in gas price from 2.1 NOK/Sm^3 to 2.5 NOK/Sm^3. On the other hand, for a change in the discount rate between 6 and 10%, and a change in CAPEX, the sensitivity is much higher for the given limits. This is also illustrated in figure 19.

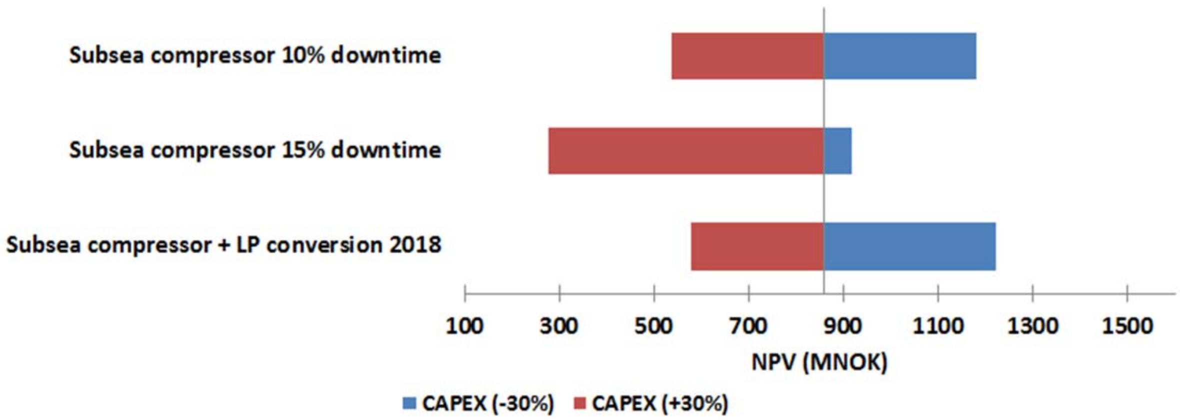

Figure 20: Tornado diagram for the CPAEX sensitivity

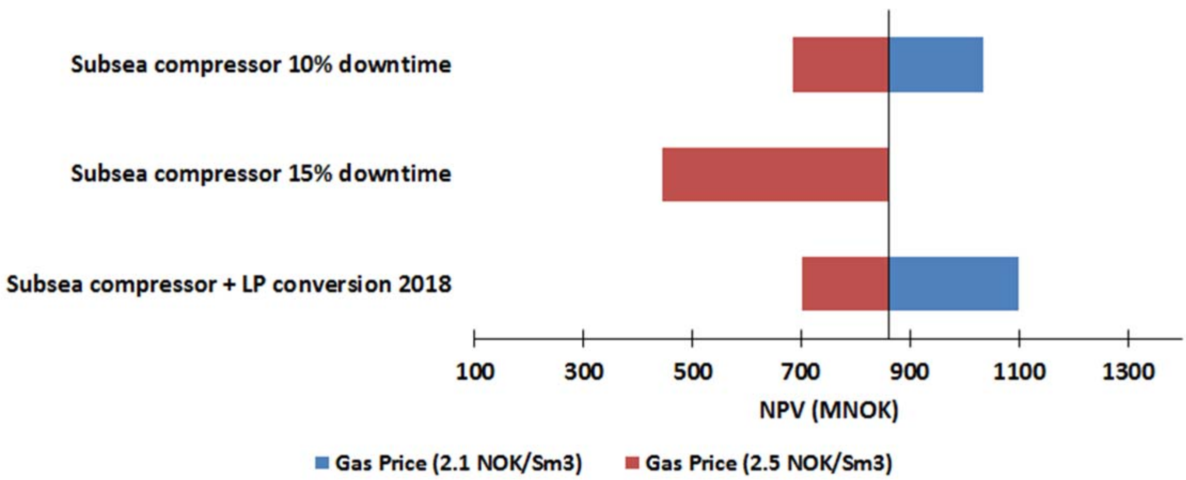

Figure 21: Tornado diagram for the gas price sensitivity

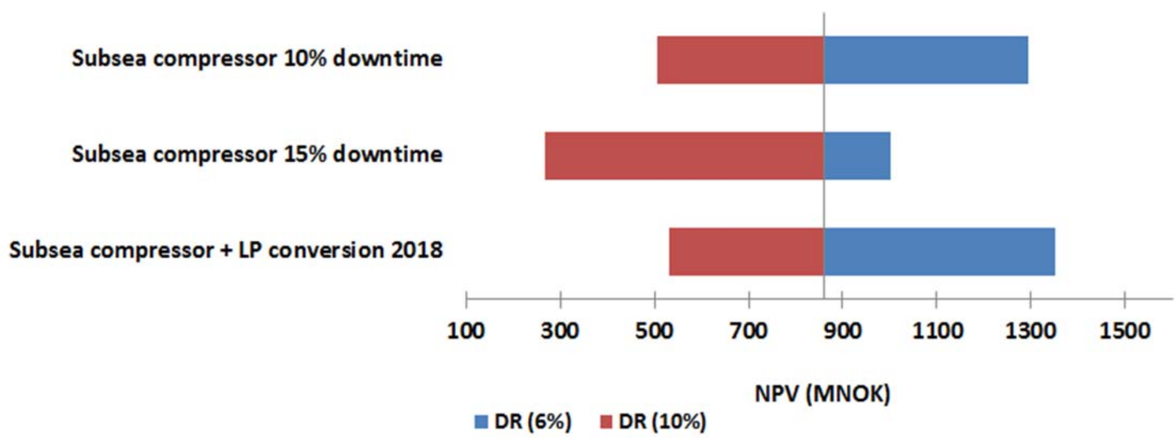

Figure 22: Tornado diagram for the discount rate sensitivity

2.4.2 Discussion

The project seems robust, as none of the tested sensitivities yield a negative NPV, assuming that the production will continue until at least 2029. The sensitivity analysis shows that the project is more sensitive to changes in CAPEX values than changes in the gas price. Even though the different discount rates have a large impact on the NPV, the discount rate is usually not the parameter with the largest variations and remains fairly constant over time.

3. Conclusions and recommendations

From this report it is evident that Statoil should carry on with the subsea WGC project on Gullfaks South. The compressor should be installed as planned by Statoil in October of 2015.

By installing the WGC module the production plateau can be extended by 2 years. The WGC module will increase the recovery factor from 0.62 to 0.71 for the L-template and from 0.63 to 0.79 for the M-template. However by going forward with low pressure modification topside in 2018, the recovery factors may be further enhanced to 0.72 and 0.81 for the L- and M-template respectively.

The economic analysis recommends going through with the WGC installation, and also making a LP conversion in 2018. The final NPV for the project will be 900.3 MNOK (for production until 2029). Sensitivity analysis shows that a change in the CAPEX has the largest impact on the project.

In addition the Gullfaks subsea WGC project gives Statoil, if successful; the option to utilize this technology on other fields other places in the world. This option will be of considerable worth.

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5. Appendices

Appendix A: Initial conditions and parameters

Gullfkas South L-M satellite system **Pre-comression Phase (Start Jan 2009)**	East Tank L-Template Fault Block 13 Brent Formation	West Tank M-Template Fault Block 14 Brent Formation	
G=GIIP-Gas cap (31 December 2008)		17,5E+9	Sm3
Condnsate from Gas Cap (31 December 2008)		4,4E+6	Sm3
oil legs: STOIIP (31 December 2008)		7,5E+6	Sm3
Gas in Solution (from oil leg)		1,9E+9	Sm3
Rs Solution Gas oil Ratio (oil leg) (31 December 2008)		248	Sm3/Sm3
rs Condensate gas ratio (gas cap) (31 December 2008)		251	Sm3/MSm3
STOIIP + Condensate (31 December 2008)	34,5E+6		Sm3
GIIP + diss.gas (31 December 2008)	54,2E+9		Sm3
Daily Plateau production rate (per template)-Precompression mode	6,0E+6	4,0E+6	Sm3/d
Wells per template (Pre compression)	4	3	
Production days per year	328	330	day
T_R	128	112	°C
Pi, initial Res pressure (01 Jan 2009)	240	210	bara
Pi, initial Res pressure (1999)	459	446	
C, inflow Back pressure coefficient	1000	700	Sm3/bar^2n
n, backpressure, exponent	0,8	0,8	
Tubing MD	3515	2800	
Tubing TVD	3100	2500	
Ct, Tubing coefficient 7" (ID=6.094")	38152,4	41163	Sm3/bar
Elevation coeff Tubing, S	0,43	0,34	
C_{FL} 12".Template L-to-Towhead 66 m (ID=) Pre-compression spool	1403054		Sm3/bar
C_{FL} 8" Template-to-Towhead 62 m (Id=)	466786		Sm3/bar
C_{FL} 12".Template M-to-Towhead 64 m (ID=) compression spool		1397663	Sm3/bar
$C_{PL\ Pipeline}$ 14" Towhead-to-GFC 14000m (ID=0.32m)	148220	148220	Sm3/bar
$C_{PL\ Pipeline}$ 8" Towhead-to-GFC 14000m (N-Line) (ID=0.197m)	32967	32967	Sm3/bar
Separator pressure GFC (Inlet Sep)	60	60	bara
Tope GFC riser pressure (High pressue mode)	65	65	
Tope GFC riser pressure (Low pressue mode)	25	25	
Gas molecular weight (Methane)	19	19	kg/kmole
Gas specific gravity	0,66	0,66	Gas specific gravity

Appendix B: Calculation sheets

Reference case

	East tank, L-template, 4 wells								West tank, M-template, 3 wells							
Calender year	qf Sm3/day	Gp Sm3	Gp/G	PR bara	Z	qw Sm3/day	pwf bara	pwh bara	qf Sm3/day	Gp Sm3	Gp/G	PR bara	Z	qw Sm3/day	pwf bara	pwh bara
2008	6,00E+06	000,0E+0	0,00	240	0,95676	1,5E+6	220	173	4,00E+06	000,0E+0	0,00	210	0,92636	1,3E+06	178	146
2009	6,00E+06	2,0E+9	0,04	231	0,95257	1,5E+6	210	165	4,00E+06	1,3E+9	0,08	194	0,92148	1,3E+06	158	129
2010	6,00E+06	3,9E+9	0,07	222	0,94835	1,5E+6	199	156	4,00E+06	2,6E+9	0,15	177	0,91818	1,3E+06	137	111
2011	6,00E+06	5,9E+9	0,11	212	0,94464	1,5E+6	189	147	4,00E+06	4,0E+9	0,23	161	0,91689	1,3E+06	116	92
2012	7,00E+06	8,2E+9	0,15	201	0,94107	1,8E+6	171	130	3,00E+06	5,0E+9	0,28	149	0,91719	1,0E+06	116	95
2013	7,00E+06	10,5E+9	0,19	190	0,93820	1,8E+6	158	119	3,00E+06	5,9E+9	0,34	137	0,91851	1,0E+06	100	81
2014	7,50E+06	13,0E+9	0,24	179	0,93593	1,9E+6	140	102	2,50E+06	6,8E+9	0,39	128	0,92035	8,3E+05	97	79
2015	8,00E+06	15,6E+9	0,29	167	0,93438	2,0E+6	121	82	2,00E+06	7,4E+9	0,42	120	0,92229	6,7E+05	96	79
2015,5	8,00E+06	16,9E+9	0,31	161	0,93393	2,0E+6	112	74	2,00E+06	7,8E+9	0,44	116	0,92338	6,7E+05	91	75
2016	7,60E+06	18,1E+9	0,33	156	0,93372	1,9E+6	109	73	1,91E+06	8,1E+9	0,46	113	0,92453	6,4E+05	88	72
2017	6,74E+06	20,3E+9	0,37	147	0,93377	1,7E+6	103	71	1,62E+06	8,6E+9	0,49	107	0,92670	5,4E+05	86	71
2018	5,98E+06	22,2E+9	0,41	138	0,93430	1,5E+6	99	70	1,37E+06	9,0E+9	0,52	102	0,92874	4,6E+05	84	70
2019	5,31E+06	24,0E+9	0,44	131	0,93515	1,3E+6	95	69	1,16E+06	9,4E+9	0,54	97	0,93061	3,9E+05	82	69
2020	4,71E+06	25,5E+9	0,47	124	0,93618	1,2E+6	92	68	9,79E+05	9,7E+9	0,56	93	0,93229	3,3E+05	81	68
2021	4,18E+06	26,9E+9	0,50	118	0,93731	1,0E+6	90	67	8,22E+05	10,0E+9	0,57	90	0,93377	2,7E+05	80	67
2022	3,70E+06	28,1E+9	0,52	113	0,93848	924,7E+3	88	67	6,86E+05	10,2E+9	0,59	88	0,93505	2,3E+05	79	67
2023	3,27E+06	29,2E+9	0,54	109	0,93965	817,7E+3	86	66	5,70E+05	10,4E+9	0,60	86	0,93614	1,9E+05	79	66
2024	2,89E+06	30,1E+9	0,56	105	0,94078	7,2E+05	85	66	4,70E+05	10,6E+9	0,61	84	0,93707	1,6E+05	78	66
2025	2,54E+06	31,0E+9	0,57	101	0,94186	6,4E+05	84	66	3,84E+05	10,7E+9	0,61	82	0,93785	1,3E+05	78	66
2026	2,23E+06	31,7E+9	0,58	98	0,94286	5,6E+05	83	66	3,12E+05	10,8E+9	0,62	81	0,93848	1,0E+05	78	66
2027	1,95E+06	32,3E+9	0,60	95	0,94378	4,9E+05	82	65	2,50E+05	10,9E+9	0,62	80	0,93900	8,3E+04	78	65
2028	1,70E+06	32,9E+9	0,61	93	0,94462	4,3E+05	82	65	1,99E+05	11,0E+9	0,63	79	0,93942	6,6E+04	78	65
2029	1,48E+06	33,4E+9	0,62	91	0,94537	3,7E+05	82	65	1,56E+05	11,0E+9	0,63	79	0,93975	5,2E+04	77	65
2030	1,28E+06	33,8E+9	0,62	89	0,94605	3,2E+05	81	65	1,21E+05	11,1E+9	0,63	78	0,94000	4,0E+04	77	65
2031	1,10E+06	34,2E+9	0,63	88	0,94664	2,8E+05	81	65	9,23E+04	11,1E+9	0,63	78	0,94020	3,1E+04	77	65
2032	9,45E+05	34,5E+9	0,64	86	0,94716	2,4E+05	81	65	6,93E+04	11,1E+9	0,64	78	0,94035	2,3E+04	77	65
2033	8,04E+05	34,7E+9	0,64	85	0,94760	2,0E+05	81	65	5,11E+04	11,1E+9	0,64	78	0,94045	1,7E+04	77	65

		2x14"													
Calender year	psep bara	ptowhead bara	ptemp bara	DpCHoke bar	psep bara	ptowhead bara	ptemp bara	Dpchoke bar	Calender year 31st december	Calender year 1st january	Total production Sm3/day	PtowheadL bara	PtowheadM bara	PtowheadA bara	error bara^2
2008	65	73	73,4	99,8	65	73	73,3	72,7	2008	2009	1,0E+07	-	-	-	-
2009	65	73	73,4	91,9	65	73	73,3	56,2	2009	2010	1,0E+07	-	-	-	-
2010	65	73	73,4	83,0	65	73	73,3	37,8	2010	2011	1,0E+07	-	-	-	-
2011	65	73	73,4	74,0	65	73	73,3	18,5	2011	2012	1,0E+07	-	-	-	-
2012	65	73	73,4	56,7	65	73	73,3	21,3	2012	2013	1,0E+07	-	-	-	-
2013	65	73	73,4	45,6	65	73	73,3	7,7	2013	2014	1,0E+07	-	-	-	-
2014	65	73	73,4	28,9	65	73	73,3	5,5	2014	2015	1,0E+07	-	-	-	-
2015	65	73	73,5	9,0	65	73	73,2	5,6	2015	2016	1,0E+07	-	-	-	-
2015,5	65	73	73,5	0,8	65	73	73,2	1,6	2015,5	2016,5	1,0E+07				
2016	65	72	72,7	0,0	65	72	72,5	0,0	2016	2017	9,5E+06	72,48	72,48	72,48	1,96E-16
2017	65	71	71,0	0,0	65	71	70,9	0,0	2017	2018	8,4E+06	70,85	70,85	70,85	6,15E-11
2018	65	70	69,7	0,0	65	70	69,6	0,0	2018	2019	7,4E+06	69,57	69,57	69,57	2,06E-11
2019	65	69	68,7	0,0	65	69	68,6	0,0	2019	2020	6,5E+06	68,56	68,56	68,56	9,93E-11
2020	65	68	67,9	0,0	65	68	67,8	0,0	2020	2021	5,7E+06	67,77	67,77	67,77	1,43E-10
2021	65	67	67,2	0,0	65	67	67,2	0,0	2021	2022	5,0E+06	67,15	67,15	67,15	7,79E-12
2022	65	67	66,7	0,0	65	67	66,7	0,0	2022	2023	4,4E+06	66,66	66,66	66,66	6,06E-13
2023	65	66	66,3	0,0	65	66	66,3	0,0	2023	2024	3,8E+06	66,28	66,28	66,28	1,35E-12
2024	65	66	66,0	0,0	65	66	66,0	0,0	2024	2025	3,4E+06	65,98	65,98	65,98	7,99E-11
2025	65	66	65,8	0,0	65	66	65,7	0,0	2025	2026	2,9E+06	65,75	65,75	65,75	3,87E-13
2026	65	66	65,6	0,0	65	66	65,6	0,0	2026	2027	2,5E+06	65,56	65,56	65,56	1,81E-11
2027	65	65	65,4	0,0	65	65	65,4	0,0	2027	2028	2,2E+06	65,42	65,42	65,42	9,59E-14
2028	65	65	65,3	0,0	65	65	65,3	0,0	2028	2029	1,9E+06	65,32	65,32	65,32	8,13E-13
2029	65	65	65,2	0,0	65	65	65,2	0,0	2029	2030	1,6E+06	65,23	65,23	65,23	5,96E-13
2030	65	65	65,2	0,0	65	65	65,2	0,0	2030	2031	1,4E+06	65,17	65,17	65,17	1,22E-16
2031	65	65	65,1	0,0	65	65	65,1	0,0	2031	2032	1,2E+06	65,12	65,12	65,12	3,62E-11
2032	65	65	65,1	0,0	65	65	65,1	0,0	2032	2033	1,0E+06	65,09	65,09	65,09	1,83E-13
2033	65	65	65,1	0,0	65	65	65,1	0,0	2033	2034	8,6E+05	65,06	65,06	65,06	3,74E-12

WGC base case

East tank, L-template, 4 wells

Calender year	qf Sm3/day	Gp Sm3	Gp/G	PR bara	Z	qw Sm3/day	pwf bara	pwh bara
2008	6,00E+06	000,0E+0	0,00	240	0,95676	1,5E+6	220	173
2009	6,00E+06	2,0E+9	0,04	231	0,95257	1,5E+6	210	165
2010	6,00E+06	3,9E+9	0,07	222	0,94835	1,5E+6	199	156
2011	6,00E+06	5,9E+9	0,11	212	0,94464	1,5E+6	189	147
2012	7,00E+06	8,2E+9	0,15	201	0,94107	1,8E+6	171	130
2013	7,00E+06	10,5E+9	0,19	190	0,93820	1,8E+6	158	119
2014	7,50E+06	13,0E+9	0,24	179	0,93593	1,9E+6	140	102
2015	8,00E+06	15,6E+9	0,29	167	0,93438	2,0E+6	121	82
2015,5	8,00E+06	16,9E+9	0,31	161	0,93393	2,0E+6	112	74
2016	7,88E+06	18,2E+9	0,34	156	0,93371	2,0E+6	106	68
2017	7,71E+06	20,7E+9	0,38	145	0,93385	1,9E+6	91	53
2017,6	7,62E+06	22,2E+9	0,41	138	0,93428	1,9E+6	81	42
2018	7,33E+06	23,1E+9	0,43	134	0,93468	1,8E+6	78	41
2019	6,58E+06	25,3E+9	0,47	125	0,93598	1,6E+6	72	39
2020	5,91E+06	27,2E+9	0,50	117	0,93760	1,5E+6	67	38
2021	5,31E+06	28,9E+9	0,53	110	0,93939	1,3E+6	63	37
2022	4,76E+06	30,5E+9	0,56	103	0,94128	1,2E+6	60	37
2023	4,27E+06	31,9E+9	0,59	97	0,94318	1,1E+6	58	37
2023,5	4,05E+06	32,6E+9	0,60	94	0,94412	1,0E+6	57	37
2024	3,99E+06	33,2E+9	0,61	92	0,94515	1,0E+06	53	34
2025	3,92E+06	34,5E+9	0,64	86	0,94725	9,8E+05	44	25
2025,3	3,90E+06	34,9E+9	0,64	85	0,94786	9,7E+05	42	22
2026	3,67E+06	35,7E+9	0,66	81	0,94937	9,2E+05	39	21
2027	3,34E+06	36,8E+9	0,68	76	0,95142	8,3E+05	37	20
2028	3,04E+06	37,8E+9	0,70	72	0,95338	7,6E+05	35	20
2029	2,77E+06	38,7E+9	0,71	68	0,95527	6,9E+05	34	20
2030	2,53E+06	39,5E+9	0,73	65	0,95705	6,3E+05	32	20
2031	2,31E+06	40,3E+9	0,74	62	0,95875	5,8E+05	31	20
2032	2,11E+06	41,0E+9	0,76	59	0,96035	5,3E+05	30	20
2033	1,94E+06	41,6E+9	0,77	56	0,96186	4,8E+05	29	20

West tank, M-template, 3 wells

Calender year	qf Sm3/day	Gp Sm3	Gp/G	PR bara	Z	qw Sm3/day	pwf bara	pwh bara
2008	4,00E+06	000,0E+0	0,00	210	0,92636	1,3E+06	178	146
2009	4,00E+06	1,3E+9	0,08	194	0,92148	1,3E+06	158	129
2010	4,00E+06	2,6E+9	0,15	177	0,91818	1,3E+06	137	111
2011	4,00E+06	4,0E+9	0,23	161	0,91689	1,3E+06	116	92
2012	3,00E+06	5,0E+9	0,28	149	0,91719	1,0E+06	116	95
2013	3,00E+06	5,9E+9	0,34	137	0,91851	1,0E+06	100	81
2014	2,50E+06	6,8E+9	0,39	128	0,92035	8,3E+05	97	79
2015	2,00E+06	7,4E+9	0,42	120	0,92229	6,7E+05	96	79
2015,5	2,00E+06	7,8E+9	0,44	116	0,92338	6,7E+05	91	75
2016	2,12E+06	8,1E+9	0,46	112	0,92480	7,1E+05	83	68
2017	2,29E+06	8,9E+9	0,51	103	0,92804	7,6E+05	66	53
2017,6	2,38E+06	9,4E+9	0,53	98	0,93025	7,9E+05	55	42
2018	2,26E+06	9,6E+9	0,55	95	0,93172	7,5E+05	53	41
2019	1,95E+06	10,3E+9	0,59	87	0,93527	6,5E+05	50	39
2020	1,68E+06	10,8E+9	0,62	81	0,93862	5,6E+05	48	38
2021	1,45E+06	11,3E+9	0,65	75	0,94172	4,8E+05	46	37
2022	1,24E+06	11,7E+9	0,67	71	0,94452	4,1E+05	46	37
2023	1,05E+06	12,1E+9	0,69	67	0,94702	3,5E+05	45	37
2023,5	9,79E+05	12,2E+9	0,70	65	0,94816	3,3E+05	45	37
2024	1,01E+06	12,4E+9	0,71	63	0,94951	3,4E+05	41	34
2025	1,08E+06	12,7E+9	0,73	58	0,95231	3,6E+05	31	25
2025,3	1,10E+06	12,9E+9	0,73	57	0,95311	3,7E+05	28	22
2026	1,02E+06	13,1E+9	0,75	55	0,95505	3,4E+05	26	20
2027	8,97E+05	13,4E+9	0,76	51	0,95752	3,0E+05	26	20
2028	7,90E+05	13,6E+9	0,78	48	0,95976	2,6E+05	25	20
2029	6,98E+05	13,9E+9	0,79	45	0,96179	2,3E+05	25	20
2030	6,17E+05	14,1E+9	0,80	43	0,96362	2,1E+05	25	20
2031	5,47E+05	14,3E+9	0,81	41	0,96527	1,8E+05	24	20
2032	4,86E+05	14,4E+9	0,82	39	0,96677	1,6E+05	24	20
2033	4,31E+05	14,6E+9	0,83	37	0,96811	1,4E+05	24	20

2x14''

Calender year	psep bara	ptowhead bara	ptemp bara	DpCHoke bar	psep bara	ptowhead bara	ptemp bara	Dpchoke bar
2008	65	73,2	73,4	99,8	65	73,2	73,3	72,7
2009	65	73,2	73,4	91,9	65	73,2	73,3	56,2
2010	65	73,2	73,4	83,0	65	73,2	73,3	37,8
2011	65	73,2	73,4	74,0	65	73,2	73,3	18,5
2012	65	73,2	73,4	56,7	65	73,2	73,3	21,3
2013	65	73,2	73,4	45,6	65	73,2	73,3	7,7
2014	65	73,2	73,4	28,9	65	73,2	73,3	5,5
2015	65	73,2	73,5	9,0	65	73,2	73,2	5,6
2015,5	65	73,2	73,5	0,8	65	73,2	73,2	1,6
2016	65	73,2	73,4		65	73,2	73,2	
2017	65	73,2	73,4		65	73,2	73,3	
2017,6	65	73,2	73,4		65	73,2	73,3	
2018	65	72,6	72,8		65	72,6	72,6	
2019	65	71,1	71,2		65	71,1	71,1	
2020	65	69,9	70,0		65	69,9	69,9	
2021	65	68,9	69,0		65	68,9	68,9	
2022	65	68,1	68,2		65	68,1	68,1	
2023	65	67,4	67,5		65	67,4	67,4	
2023,5	65	67,2	67,2		65	67,2	67,2	
2024	65	67,2	67,2		65	67,2	67,2	
2025	65	67,2	67,2		65	67,2	67,2	
2025,3	65	67,2	67,2		65	67,2	67,2	
2026	65	66,9	66,9		65	66,9	66,9	
2027	65	66,5	66,6		65	66,5	66,6	
2028	65	66,3	66,3		65	66,3	66,3	
2029	65	66,0	66,1		65	66,0	66,0	
2030	65	65,9	65,9		65	65,9	65,9	
2031	65	65,7	65,7		65	65,7	65,7	
2032	65	65,6	65,6		65	65,6	65,6	
2033	65	65,5	65,5		65	65,5	65,5	

Calender year	Total production Sm3/day	PtowheadL bara	PtowheadM bara	PtowheadA bara	error bara^2	dPcomp bara	rp comp	dPcomp, fi bara	error bara^2
2008	1,00E+07	-	-	-	-	-	-	-	-
2009	1,00E+07	-	-	-	-	-	-	-	-
2010	1,00E+07	-	-	-	-	-	-	-	-
2011	1,00E+07	-	-	-	-	-	-	-	-
2012	1,00E+07	-	-	-	-	-	-	-	-
2013	1,00E+07	-	-	-	-	-	-	-	-
2014	1,00E+07	-	-	-	-	-	-	-	-
2015	1,00E+07	-	-	-	-	-	-	-	-
2015,5	1,00E+07								
2016	1,00E+07	67,71	67,67	67,69	9,99E-04	5,54	1,08		
2017	1,00E+07	52,66	52,62	52,64	1,00E-03	20,59	1,39		
2017,6	1,00E+07	41,99	41,95	41,97	1,00E-03	31,26	1,74		
2018	9,59E+06	40,58	40,62	40,60	1,00E-03	32,00	1,79	32	2,44E-26
2019	8,52E+06	39,05	39,10	39,07	1,00E-03	32,00	1,82	32	3,22E-14
2020	7,60E+06	37,85	37,89	37,87	1,00E-03	32,00	1,85	32	3,01E-15
2021	6,76E+06	37,21	37,26	37,24	1,00E-03	31,65	1,85	32	1,22E-01
2022	6,00E+06	37,18	37,22	37,20	1,00E-03	30,88	1,83	32	1,26E+00
2023	5,32E+06	37,24	37,28	37,26	1,00E-03	30,18	1,81	32	3,32E+00
2023,5	5,03E+06	37,09	37,14	37,12	1,00E-03	30,06	1,81	32	3,75E+00
2024	5,00E+06	33,56	33,64	33,60	2,55E-03	33,55	1,41		
2025	5,00E+06	24,61	24,71	24,66	5,17E-03	42,49	1,65		
2025,3	5,00E+06	21,66	21,70	21,68	1,00E-03	45,47	1,76		
2026	4,69E+06	20,40	20,44	20,42	1,00E-03	46,48	1,81	60	1,83E+02
2027	4,23E+06	20,29	20,34	20,31	1,00E-03	46,24	1,81	60	1,89E+02
2028	3,83E+06	20,21	20,25	20,23	1,00E-03	46,04	1,81	60	1,95E+02
2029	3,47E+06	20,14	20,18	20,16	9,99E-04	45,88	1,81	60	1,99E+02
2030	3,14E+06	20,08	20,13	20,10	1,00E-03	45,76	1,81	60	2,03E+02
2031	2,86E+06	20,04	20,08	20,06	1,00E-03	45,65	1,81	60	2,06E+02
2032	2,60E+06	20,00	20,04	20,02	1,00E-03	45,57	1,81	60	2,08E+02
2033	2,37E+06	19,97	20,01	19,99	1,00E-03	45,50	1,81	60	2,10E+02

WGC increased downtime (15 %)

	East tank, L-template, 4 wells								West tank, M-template, 3 wells							
Calender year	qf Sm3/day	Gp Sm3	Gp/G	PR bara	Z	qw Sm3/day	pwf bara	pwh bara	qf Sm3/day	Gp Sm3	Gp/G	PR bara	Z	qw Sm3/day	pwf bara	pwh bara
2008	6,00E+06	000,0E+0	0,00	240	0,95676	1,5E+6	220	173	4,00E+06	000,0E+0	0,00	210	0,92636	1,3E+06	178	146
2009	6,00E+06	2,0E+9	0,04	231	0,95257	1,5E+6	210	165	4,00E+06	1,3E+9	0,08	194	0,92148	1,3E+06	158	129
2010	6,00E+06	3,9E+9	0,07	222	0,94835	1,5E+6	199	156	4,00E+06	2,6E+9	0,15	177	0,91818	1,3E+06	137	111
2011	6,00E+06	5,9E+9	0,11	212	0,94464	1,5E+6	189	147	4,00E+06	4,0E+9	0,23	161	0,91689	1,3E+06	116	92
2012	7,00E+06	8,2E+9	0,15	201	0,94107	1,8E+6	171	130	3,00E+06	5,0E+9	0,28	149	0,91719	1,0E+06	116	95
2013	7,00E+06	10,5E+9	0,19	190	0,93820	1,8E+6	158	119	3,00E+06	5,9E+9	0,34	137	0,91851	1,0E+06	100	81
2014	7,50E+06	13,0E+9	0,24	179	0,93593	1,9E+6	140	102	2,50E+06	6,8E+9	0,39	128	0,92035	8,3E+05	97	79
2015	8,00E+06	15,6E+9	0,29	167	0,93438	2,0E+6	121	82	2,00E+06	7,4E+9	0,42	120	0,92229	6,7E+05	96	79
2015,5	8,00E+06	16,9E+9	0,31	161	0,93393	2,0E+6	112	74	2,00E+06	7,8E+9	0,44	116	0,92338	6,7E+05	91	75
2016	7,89E+06	18,0E+9	0,33	156	0,93372	2,0E+6	106	69	2,11E+06	8,1E+9	0,46	113	0,92463	7,0E+05	84	68
2017	7,72E+06	20,4E+9	0,38	146	0,93379	1,9E+6	92	55	2,28E+06	8,8E+9	0,50	104	0,92761	7,6E+05	68	55
2017,8	7,61E+06	22,3E+9	0,41	138	0,93432	1,9E+6	80	42	2,39E+06	9,4E+9	0,54	98	0,93043	8,0E+05	54	41
2018	7,46E+06	22,7E+9	0,42	136	0,93450	1,9E+6	79	41	2,32E+06	9,5E+9	0,54	96	0,93111	7,7E+05	53	41
2019	6,74E+06	24,8E+9	0,46	127	0,93566	1,7E+6	73	40	2,01E+06	10,1E+9	0,58	89	0,93449	6,7E+05	51	39
2020	6,09E+06	26,7E+9	0,49	119	0,93712	1,5E+6	69	38	1,75E+06	10,7E+9	0,61	83	0,93772	5,8E+05	48	38
2021	5,50E+06	28,4E+9	0,52	112	0,93878	1,4E+6	65	38	1,52E+06	11,2E+9	0,64	77	0,94072	5,1E+05	47	38
2022	4,97E+06	29,9E+9	0,55	106	0,94053	1,2E+6	61	37	1,31E+06	11,6E+9	0,66	72	0,94347	4,4E+05	46	37
2023	4,48E+06	31,3E+9	0,58	100	0,94233	1,1E+6	59	37	1,13E+06	11,9E+9	0,68	68	0,94596	3,8E+05	46	37
2024	4,05E+06	32,5E+9	0,60	94	0,94413	1,0E+06	57	37	9,77E+05	12,2E+9	0,70	65	0,94819	3,3E+05	45	37
2024,05	4,04E+06	32,6E+9	0,60	94	0,94416	1,0E+06	57	37	9,78E+05	12,2E+9	0,70	65	0,94821	3,3E+05	45	37
2025	3,96E+06	33,8E+9	0,62	89	0,94604	9,9E+05	49	30	1,04E+06	12,5E+9	0,72	61	0,95068	3,5E+05	37	30
2025,6	3,92E+06	34,5E+9	0,64	86	0,94727	9,8E+05	44	25	1,08E+06	12,8E+9	0,73	58	0,95242	3,6E+05	31	24
2026	3,89E+06	35,0E+9	0,65	84	0,94807	9,7E+05	41	21	1,10E+06	12,9E+9	0,74	57	0,95341	3,7E+05	27	21
2027	3,55E+06	36,1E+9	0,67	80	0,95005	8,9E+05	39	21	9,74E+05	13,2E+9	0,75	53	0,95589	3,2E+05	26	21
2028	3,24E+06	37,1E+9	0,68	75	0,95196	8,1E+05	37	21	8,62E+05	13,5E+9	0,77	50	0,95815	2,9E+05	26	21
2029	2,97E+06	38,0E+9	0,70	71	0,95379	7,4E+05	35	21	7,65E+05	13,7E+9	0,78	47	0,96021	2,5E+05	25	20
2030	2,72E+06	38,8E+9	0,72	68	0,95555	6,8E+05	34	20	6,80E+05	13,9E+9	0,79	45	0,96208	2,3E+05	25	20
2031	2,50E+06	39,6E+9	0,73	65	0,95722	6,2E+05	32	20	6,06E+05	14,1E+9	0,81	42	0,96378	2,0E+05	25	20
2032	2,29E+06	40,3E+9	0,74	62	0,95881	5,7E+05	31	20	5,40E+05	14,3E+9	0,81	40	0,96532	1,8E+05	25	20
2033	2,11E+06	41,0E+9	0,76	59	0,96032	5,3E+05	30	20	4,82E+05	14,4E+9	0,82	39	0,96672	1,6E+05	25	20

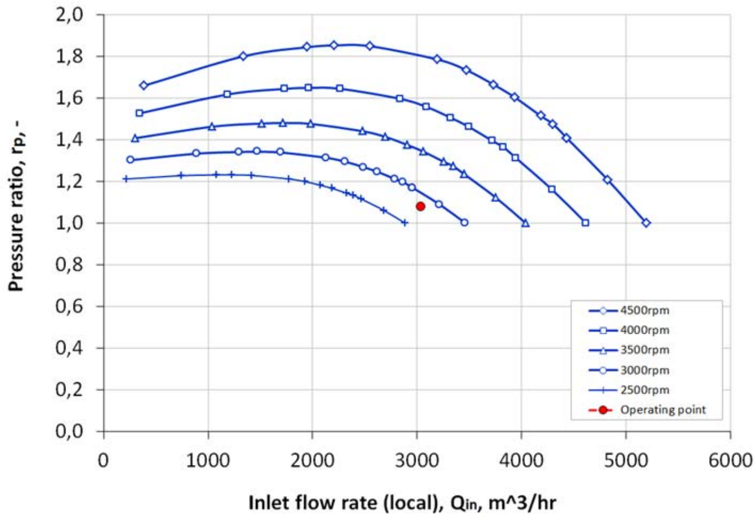
		2x14"																	
Calender year	psep bara	ptowhead bara	ptemp bara	DpCHoke bar	psep bara	ptowhead bara	ptemp bara	Dpchoke bar	Calender year 31st december	Calender year 1st january	Total production Sm3/day	PtowheadL bara	PtowheadM bara	PtowheadA bara	error bara^2	dPcomp bara	rp comp	dPcomp, fi bara	error bara^2
2008	65	73,2	73,4	99,8	65	73,2	73,3	72,7	2008	2009	1,00E+07	-	-	-	-	-	-	-	-
2009	65	73,2	73,4	91,9	65	73,2	73,3	56,2	2009	2010	1,00E+07	-	-	-	-	-	-	-	-
2010	65	73,2	73,4	83,0	65	73,2	73,3	37,8	2010	2011	1,00E+07	-	-	-	-	-	-	-	-
2011	65	73,2	73,4	74,0	65	73,2	73,3	18,5	2011	2012	1,00E+07	-	-	-	-	-	-	-	-
2012	65	73,2	73,4	56,7	65	73,2	73,3	21,3	2012	2013	1,00E+07	-	-	-	-	-	-	-	-
2013	65	73,2	73,4	45,6	65	73,2	73,3	7,7	2013	2014	1,00E+07	-	-	-	-	-	-	-	-
2014	65	73,2	73,4	28,9	65	73,2	73,3	5,5	2014	2015	1,00E+07	-	-	-	-	-	-	-	-
2015	65	73,2	73,5	9,0	65	73,2	73,2	5,6	2015	2016	1,00E+07	-	-	-	-	-	-	-	-
2015,5	65	73,2	73,5	0,8	65	73,2	73,2	1,6	2015,5	2016,5	1,00E+07								
2016	65	73,2	73,4		65	73,2	73,2		2016	2017	1,00E+07	68,51	68,47	68,49	1,00E-03	4,74	1,07		
2017	65	73,2	73,4		65	73,2	73,3		2017	2018	1,00E+07	54,57	54,52	54,54	1,00E-03	18,69	1,34		
2017,8	65	73,2	73,4		65	73,2	73,3		2017,8	2018,8	1,00E+07	41,18	41,14	41,16	1,00E-03	32,07	1,78		
2018	65	72,9	73,1		65	72,9	72,9		2018	2019	9,78E+06	40,87	40,91	40,89	1,00E-03	32,00	1,78	32	5,20E-12
2019	65	71,4	71,5		65	71,4	71,4		2019	2020	8,75E+06	39,36	39,41	39,38	1,00E-03	32,00	1,81	32	3,92E-21
2020	65	70,2	70,3		65	70,2	70,2		2020	2021	7,84E+06	38,20	38,15	38,17	1,00E-03	32,00	1,84	32	1,91E-20
2021	65	69,2	69,3		65	69,2	69,2		2021	2022	7,02E+06	37,57	37,62	37,60	1,00E-03	31,58	1,84	32	1,77E-01
2022	65	68,4	68,5		65	68,4	68,4		2022	2023	6,29E+06	37,14	37,18	37,16	1,00E-03	31,21	1,84	32	6,18E-01
2023	65	67,7	67,8		65	67,7	67,7		2023	2024	5,62E+06	37,18	37,22	37,20	1,00E-03	30,50	1,82	32	2,24E+00
2024	65	67,2	67,2		65	67,2	67,2		2024	2025	5,03E+06	37,09	37,14	37,12	1,00E-03	30,06	1,81	32	3,75E+00
2024,05	65	67,2	67,2		65	67,2	67,2		2024,05	2025,05	5,02E+06	37,13	37,09	37,11	1,00E-03	30,06	1,81	32	3,76E+00
2025	65	67,2	67,2		65	67,2	67,2		2025	2026	5,00E+06	29,95	30,07	30,01	6,48E-03	37,14	1,50		
2025,6	65	67,2	67,2		65	67,2	67,2		2025	2026	5,00E+06	24,47	24,43	24,45	1,00E-03	42,70	1,66		
2026	65	67,1	67,2		65	67,1	67,1		2026	2027	4,99E+06	20,70	20,75	20,72	1,00E-03	46,42	1,80	60	1,84E+02
2027	65	66,8	66,8		65	66,8	66,8		2027	2028	4,52E+06	20,58	20,63	20,61	9,99E-04	46,16	1,80	60	1,92E+02
2028	65	66,5	66,5		65	66,5	66,5		2028	2029	4,11E+06	20,49	20,53	20,51	1,00E-03	45,95	1,80	60	1,97E+02
2029	65	66,2	66,2		65	66,2	66,2		2029	2030	3,73E+06	20,41	20,46	20,44	1,00E-03	45,77	1,80	60	2,02E+02
2030	65	66,0	66,0		65	66,0	66,0		2030	2031	3,40E+06	20,35	20,39	20,37	1,00E-03	45,63	1,80	60	2,06E+02
2031	65	65,8	65,9		65	65,8	65,8		2031	2032	3,10E+06	20,30	20,34	20,32	1,00E-03	45,52	1,80	60	2,10E+02
2032	65	65,7	65,7		65	65,7	65,7		2032	2033	2,83E+06	20,26	20,30	20,28	1,00E-03	45,42	1,80	60	2,13E+02
2033	65	65,6	65,6		65	65,6	65,6		2033	2034	2,59E+06	20,22	20,26	20,24	1,00E-03	45,34	1,80	60	2,15E+02

WGC + LP2018

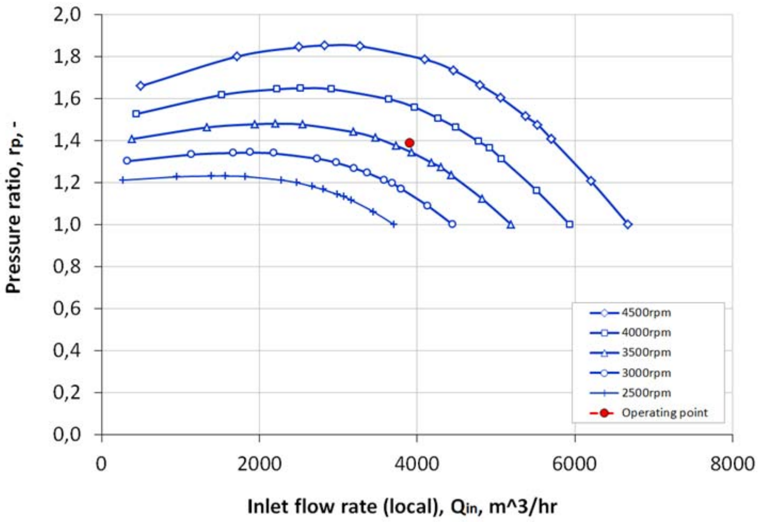
	East tank, L-template, 4 wells								West tank, M-template, 3 wells									2x14"															
Calender year	qf	Gp	Gp/G	PR	Z	qw	pwf	pwh	qf	Gp	Gp/G	PR	Z	qw	pwf	pwh	psep	ptowhead	ptemp	DpCHoke	psep	ptowhead	ptemp	Dpchoke	Total production	PtowheadL	PtowheadM	PtowheadA	error	dPcomp	rp comp	dPcomp, fi	error
	Sm3/day	Sm3		bara		Sm3/day	bara	bara	Sm3/day	Sm3		bara		Sm3/day	bara	bara	bara	bara	bara	bar	bara	bara	bara	bar	Sm3/day	bara	bara	bara	bara^2	bara		bara	bara^2
2008	6,00E+06	000,0E+0	0,00	240	0,95676	1,5E+6	220	173	4,00E+06	000,0E+0	0,00	210	0,92636	1,3E+06	178	146	65	73,2	73,4	99,8	65	73,2	73,3	72,7	1,00E+07	-	-	-	-	-	-	-	-
2009	6,00E+06	2,0E+9	0,04	231	0,95257	1,5E+6	210	165	4,00E+06	1,3E+9	0,08	194	0,92148	1,3E+06	158	129	65	73,2	73,4	91,9	65	73,2	73,3	56,2	1,00E+07	-	-	-	-	-	-	-	-
2010	6,00E+06	3,9E+9	0,07	222	0,94835	1,5E+6	199	156	4,00E+06	2,6E+9	0,15	177	0,91818	1,3E+06	137	111	65	73,2	73,4	83,0	65	73,2	73,3	37,8	1,00E+07	-	-	-	-	-	-	-	-
2011	6,00E+06	5,9E+9	0,11	212	0,94464	1,5E+6	189	147	4,00E+06	4,0E+9	0,23	161	0,91689	1,3E+06	116	92	65	73,2	73,4	74,0	65	73,2	73,3	18,5	1,00E+07	-	-	-	-	-	-	-	-
2012	7,00E+06	8,2E+9	0,15	201	0,94107	1,8E+6	171	130	3,00E+06	5,0E+9	0,28	149	0,91719	1,0E+06	116	95	65	73,2	73,4	56,7	65	73,2	73,3	21,3	1,00E+07	-	-	-	-	-	-	-	-
2013	7,00E+06	10,5E+9	0,19	190	0,93820	1,8E+6	158	119	3,00E+06	5,9E+9	0,34	137	0,91851	1,0E+06	100	81	65	73,2	73,4	45,6	65	73,2	73,3	7,7	1,00E+07	-	-	-	-	-	-	-	-
2014	7,50E+06	13,0E+9	0,24	179	0,93593	1,9E+6	140	102	2,50E+06	6,8E+9	0,39	128	0,92035	8,3E+05	97	79	65	73,2	73,4	28,9	65	73,2	73,3	5,5	1,00E+07	-	-	-	-	-	-	-	-
2015	8,00E+06	15,6E+9	0,29	167	0,93438	2,0E+6	121	82	2,00E+06	7,4E+9	0,42	120	0,92229	6,7E+05	96	79	65	73,2	73,5	9,0	65	73,2	73,2	5,6	1,00E+07	-	-	-	-	-	-	-	-
2015,5	8,00E+06	16,9E+9	0,31	161	0,93393	2,0E+6	112	74	2,00E+06	7,8E+9	0,44	116	0,92338	6,7E+05	91	75	65	73,2	73,5	0,8	65	73,2	73,2	1,6	1,00E+07								
2016	7,88E+06	18,2E+9	0,34	156	0,93371	2,0E+6	106	68	2,12E+06	8,1E+9	0,46	112	0,92480	7,1E+05	83	68	65	73,2	73,4		65	73,2	73,2		1,00E+07	67,71	67,67	67,69	9,99E-04	5,54	1,08		
2017	7,71E+06	20,7E+9	0,38	145	0,93385	1,9E+6	91	53	2,29E+06	8,9E+9	0,51	103	0,92804	7,6E+05	66	53	65	73,2	73,4		65	73,2	73,3		1,00E+07	52,66	52,62	52,64	1,00E-03	20,59	1,39		
2018	7,57E+06	23,2E+9	0,43	134	0,93472	1,9E+6	74	34	2,43E+06	9,7E+9	0,55	94	0,93203	8,1E+05	46	33	25	42,0	42,3		25	42,0	42,0		1,00E+07	33,12	33,08	33,10	1,00E-03	8,89	1,27	32	5,34E+02
2018,1	7,55E+06	23,4E+9	0,43	133	0,93483	1,9E+6	73	32	2,45E+06	9,8E+9	0,56	93	0,93229	8,2E+05	44	31	25	42,0	42,3		25	42,0	42,0		1,00E+07	31,09	31,14	31,12	1,00E-03	10,87	1,35	32	4,46E+02
2019	7,04E+06	25,5E+9	0,47	124	0,93616	1,8E+6	64	23	2,25E+06	10,4E+9	0,60	85	0,93622	7,5E+05	34	22	25	40,1	40,4		25	40,1	40,1		9,29E+06	22,12	22,17	22,14	1,00E-03	17,94	1,81	32	1,98E+02
2020	6,34E+06	27,6E+9	0,51	115	0,93796	1,6E+6	58	21	1,95E+06	11,1E+9	0,63	78	0,94022	6,5E+05	31	21	25	37,5	37,8		25	37,5	37,5		8,29E+06	20,74	20,70	20,72	1,00E-03	16,78	1,81	32	2,32E+02
2021	5,71E+06	29,4E+9	0,54	108	0,93997	1,4E+6	53	21	1,69E+06	11,6E+9	0,66	72	0,94398	5,6E+05	29	20	25	35,3	35,6		25	35,3	35,3		7,39E+06	20,20	20,16	20,18	1,00E-03	15,14	1,75	32	2,84E+02
2022	5,14E+06	31,1E+9	0,57	100	0,94211	1,3E+6	49	20	1,46E+06	12,1E+9	0,69	66	0,94744	4,9E+05	28	20	25	33,5	33,7		25	33,5	33,5		6,61E+06	20,12	20,17	20,14	1,00E-03	13,35	1,66	32	3,48E+02
2023	4,61E+06	32,6E+9	0,60	94	0,94427	1,2E+6	46	22	1,25E+06	12,5E+9	0,72	61	0,95056	4,2E+05	28	21	25	31,9	32,0		25	31,9	31,9		5,86E+06	21,52	21,48	21,50	1,00E-03	10,37	1,48	32	4,68E+02
2024	4,19E+06	34,0E+9	0,63	88	0,94644	1,0E+06	43	21	1,10E+06	12,9E+9	0,74	57	0,95343	3,7E+05	27	21	25	30,7	30,9		25	30,7	30,7		5,29E+06	20,82	20,87	20,84	1,00E-03	9,87	1,47	32	4,90E+02
2025	3,82E+06	35,3E+9	0,65	83	0,94858	9,5E+05	40	20	9,77E+05	13,2E+9	0,75	53	0,95607	3,3E+05	26	20	25	29,8	29,9		25	29,8	29,8		4,79E+06	19,98	20,02	20,00	1,00E-03	9,77	1,49	32	4,94E+02
2026	3,45E+06	36,4E+9	0,67	78	0,95065	8,6E+05	38	21	8,50E+05	13,5E+9	0,77	50	0,95844	2,8E+05	26	20	25	28,9	29,0		25	28,9	28,9		4,30E+06	20,49	20,44	20,46	1,00E-03	8,44	1,41	32	5,55E+02
2027	3,14E+06	37,4E+9	0,69	74	0,95265	7,9E+05	36	20	7,50E+05	13,7E+9	0,78	47	0,96059	2,5E+05	25	20	25	28,2	28,3		25	28,2	28,2		3,89E+06	20,37	20,32	20,35	1,00E-03	7,89	1,39	32	5,81E+02
2028	2,84E+06	38,4E+9	0,71	70	0,95455	7,1E+05	35	21	6,50E+05	13,9E+9	0,80	44	0,96249	2,2E+05	26	21	25	27,6	27,7		25	27,6	27,6		3,49E+06	20,95	20,91	20,93	1,00E-03	6,71	1,32	32	6,40E+02
2029	2,60E+06	39,2E+9	0,72	66	0,95637	6,5E+05	33	21	5,80E+05	14,1E+9	0,81	42	0,96423	1,9E+05	25	21	25	27,2	27,3		25	27,2	27,2		3,18E+06	20,57	20,61	20,59	1,00E-03	6,62	1,32	32	6,44E+02
2030	2,39E+06	40,0E+9	0,74	63	0,95810	6,0E+05	31	20	5,25E+05	14,3E+9	0,82	40	0,96582	1,8E+05	24	20	25	26,9	26,9		25	26,9	26,9		2,92E+06	19,98	20,02	20,00	1,00E-03	6,87	1,34	32	6,32E+02
2031	2,16E+06	40,7E+9	0,75	60	0,95972	5,4E+05	31	21	4,50E+05	14,5E+9	0,83	38	0,96721	1,5E+05	25	21	25	26,5	26,6		25	26,5	26,5		2,61E+06	20,80	20,75	20,78	1,00E-03	5,73	1,28	32	6,90E+02
2032	1,98E+06	41,4E+9	0,76	57	0,96124	5,0E+05	30	21	4,00E+05	14,6E+9	0,83	36	0,96846	1,3E+05	25	21	25	26,3	26,3		25	26,3	26,3		2,38E+06	20,75	20,70	20,73	1,00E-03	5,53	1,27	32	7,01E+02
2033	1,81E+06	41,9E+9	0,77	55	0,96267	4,5E+05	30	21	3,50E+05	14,7E+9	0,84	35	0,96957	1,2E+05	25	21	25	26,0	26,1		25	26,0	26,0		2,16E+06	20,87	20,91	20,89	1,00E-03	5,15	1,25	32	7,21E+02

Appendix C: Compressor mapping WGC

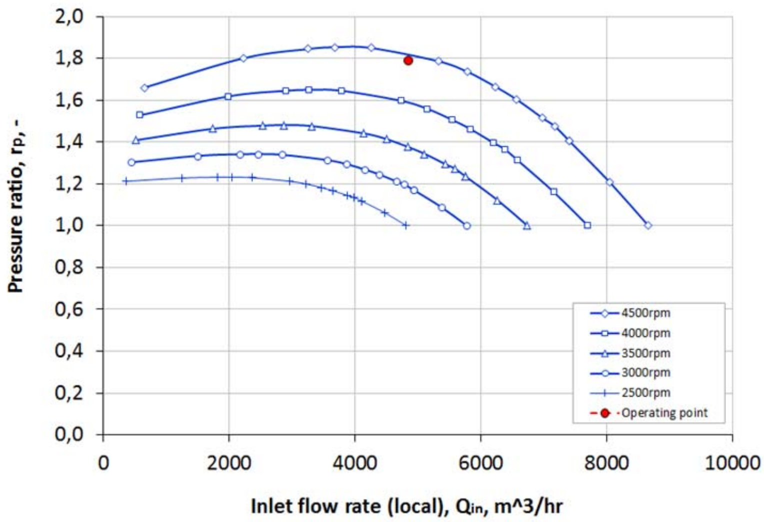
2016



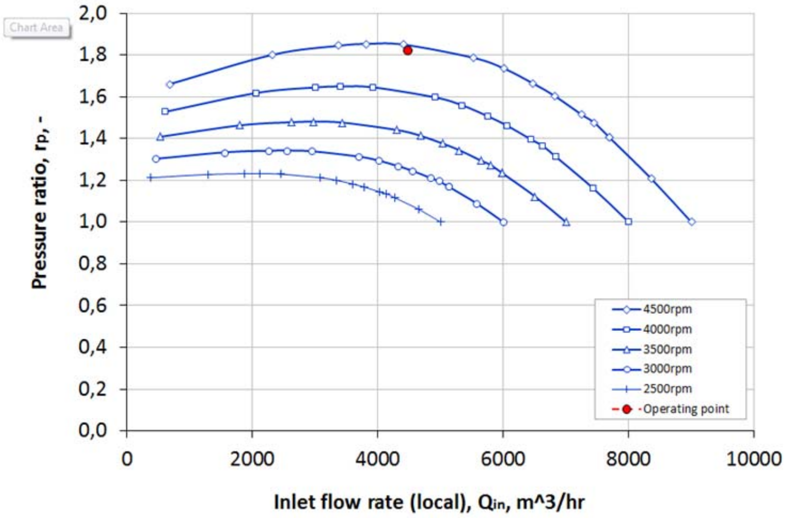
2017



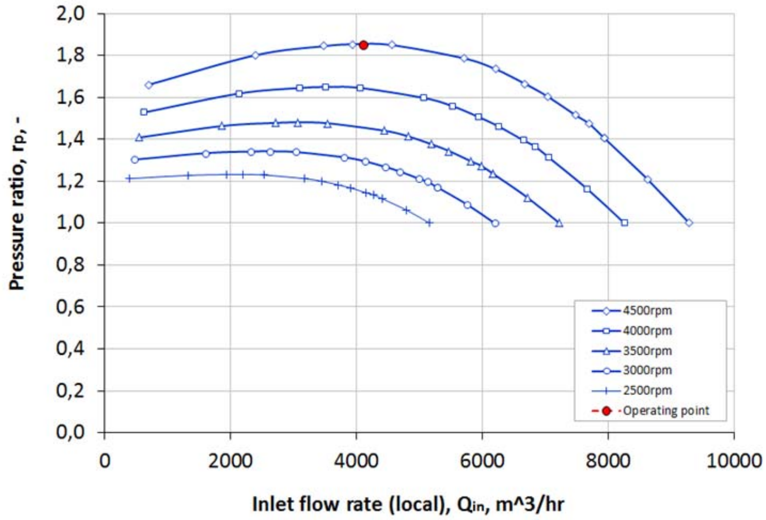
2018



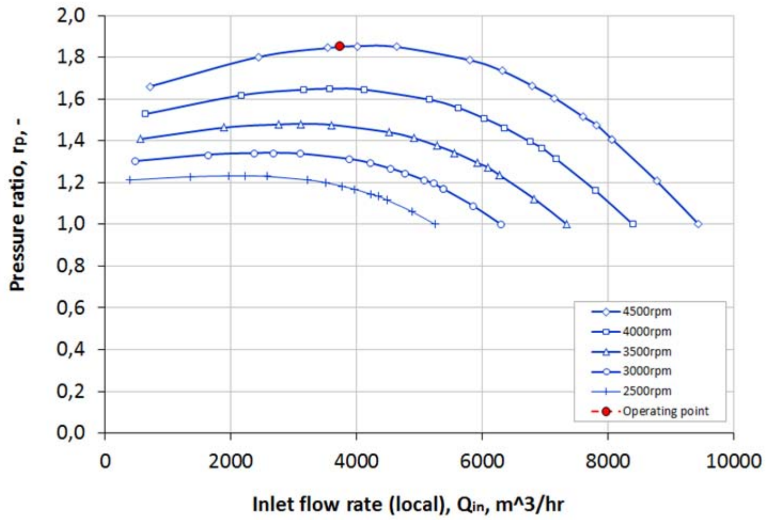
2019



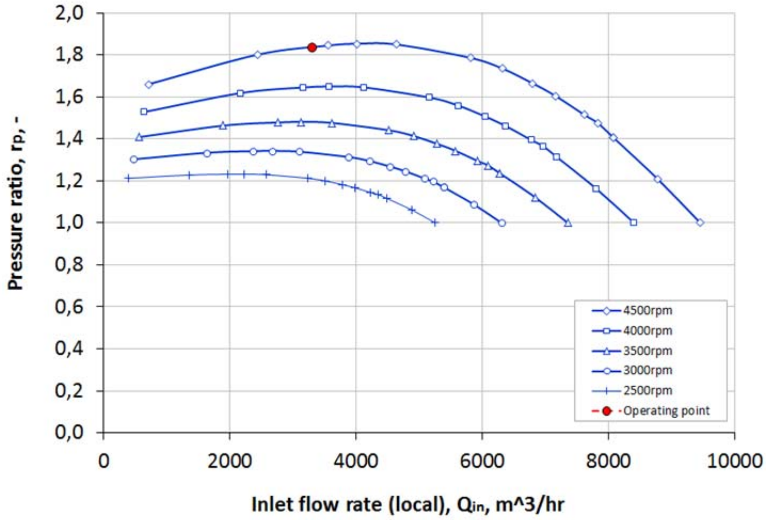
2020



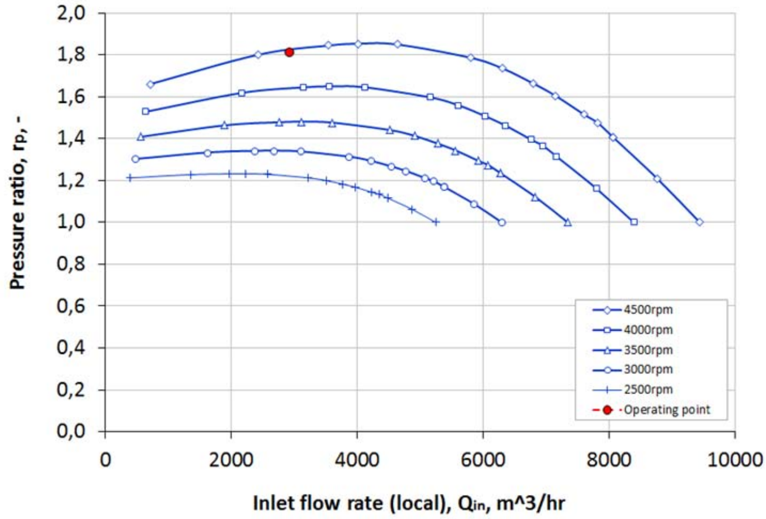
2021



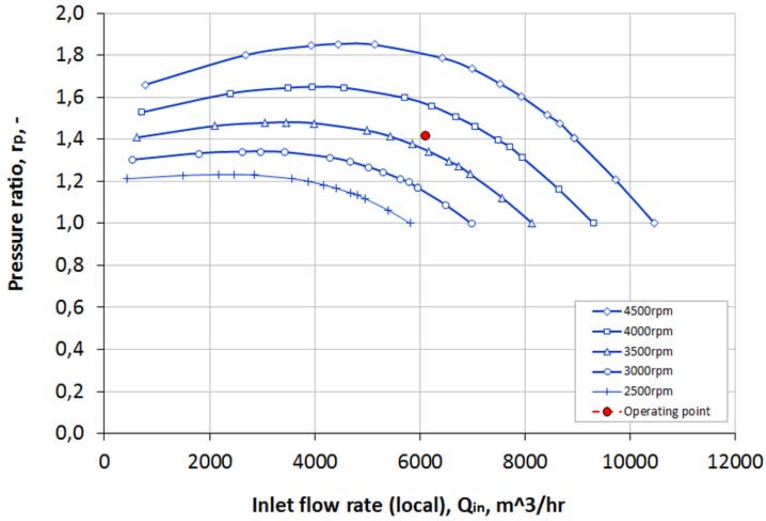
2022



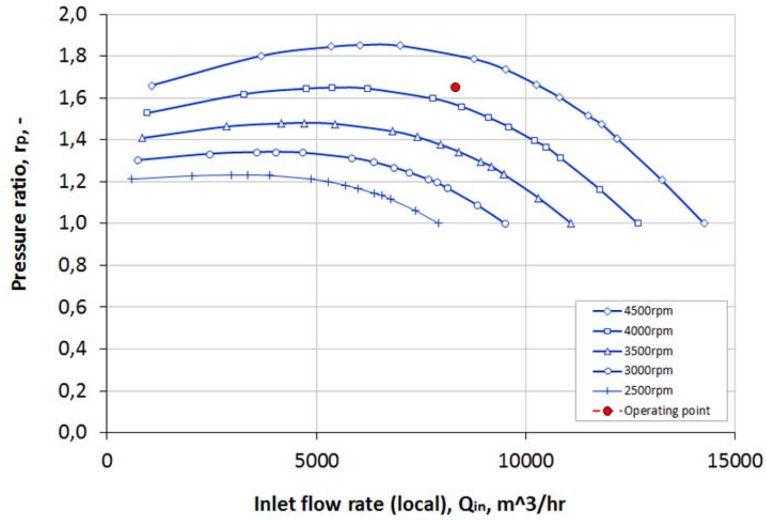
2023



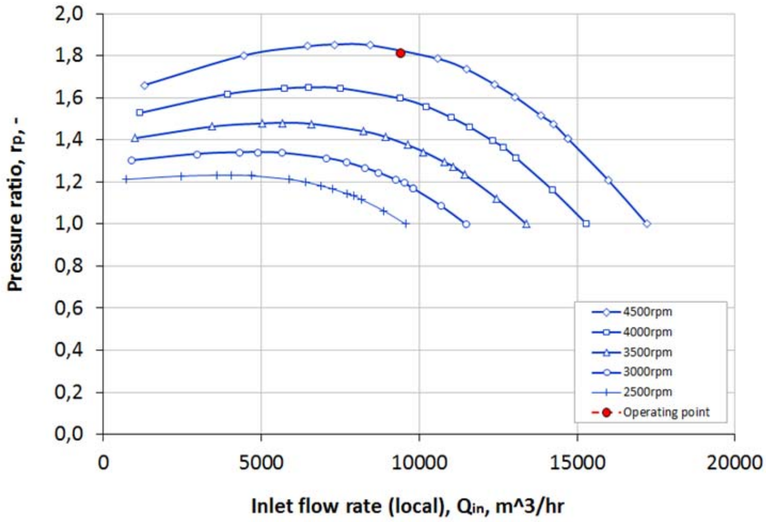
2024



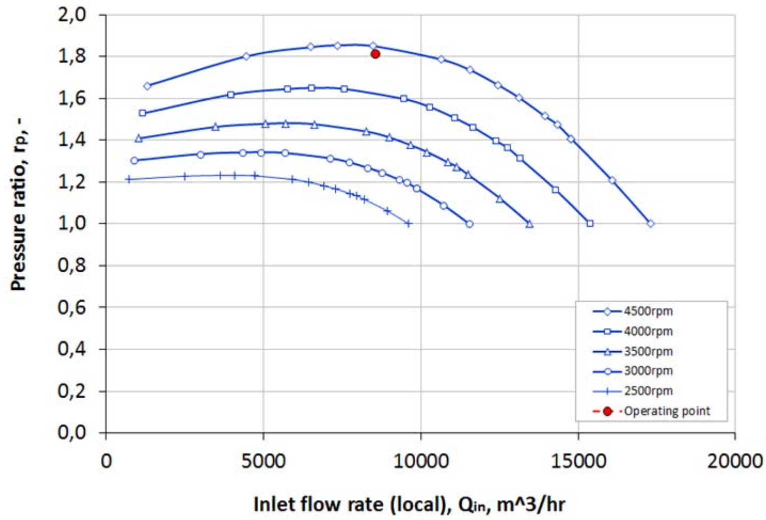
2025



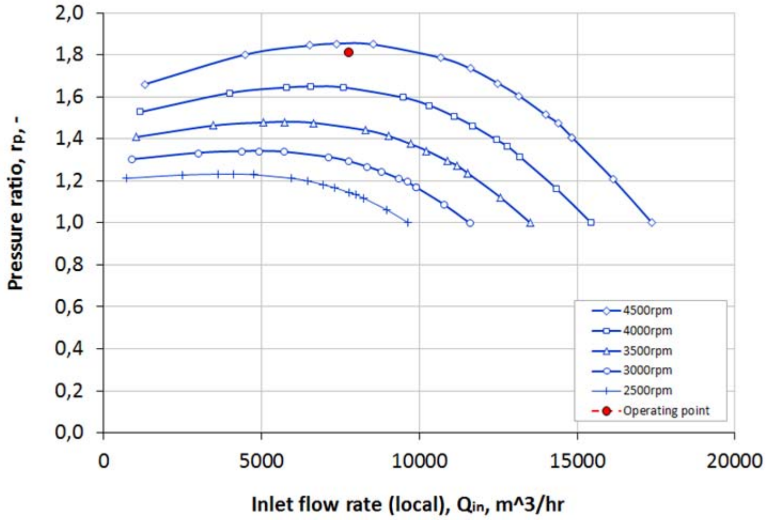
2026



2027

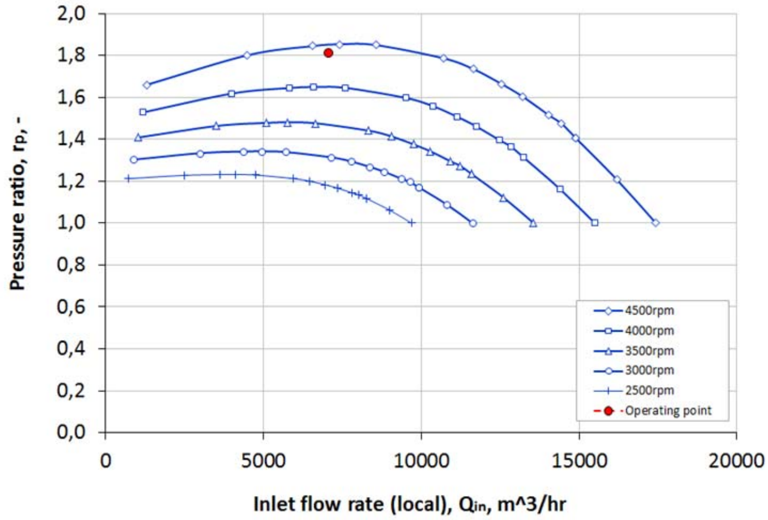


2028



2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0
5000
10000
15000
20000
Pressure ratio, rp, -
Inlet flow rate (local), Qin, m^3/hr
4500rpm
4000rpm
3500rpm
3000rpm
2500rpm
Operating point

2029



2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0
5000
10000
15000
20000
Pressure ratio, rp, -
Inlet flow rate (local), Qin, m^3/hr
4500rpm
4000rpm
3500rpm
3000rpm
2500rpm
Operating point

Appendix D: Total production of gas and condensate

	Reference case						WGC					
	Gas [Sm3/d]		Total	Condensate [Sm3/d]		Total	Gas [Sm3/d]		Total	Condensate [Sm3/d]		Total
	L-Template	M-Template	[Sm3/year]	L-Template	M-Template	[Sm3/year]	L-Template	M-Template	[Sm3/year]	L-Template	M-Template	[Sm3/year]
2013	7,00E+06	3,00E+06	3,29E+09	5,89E+02	1,02E+02	2,27E+05	7,00E+06	3,00E+06	3,29E+09	5,89E+02	1,02E+02	2,27E+05
2014	7,50E+06	2,50E+06	3,29E+09	5,58E+02	7,17E+01	2,07E+05	7,50E+06	2,50E+06	3,29E+09	5,58E+02	7,17E+01	2,07E+05
2015	8,00E+06	2,00E+06	3,28E+09	5,23E+02	5,01E+01	1,88E+05	8,00E+06	2,00E+06	3,28E+09	5,23E+02	5,01E+01	1,88E+05
2016	7,60E+06	1,91E+06	3,12E+09	4,36E+02	4,74E+01	1,59E+05	7,88E+06	2,12E+06	3,28E+09	4,52E+02	4,72E+01	1,64E+05
2017	6,74E+06	1,62E+06	2,74E+09	3,44E+02	4,69E+01	1,28E+05	7,71E+06	2,29E+06	3,28E+09	3,89E+02	4,55E+01	1,42E+05
2018	5,98E+06	1,37E+06	2,41E+09	2,75E+02	4,57E+01	1,05E+05	7,33E+06	2,26E+06	3,15E+09	3,28E+02	3,99E+01	1,21E+05
2019	5,31E+06	1,16E+06	2,12E+09	2,24E+02	4,19E+01	8,72E+04	6,58E+06	1,95E+06	2,80E+09	2,64E+02	3,12E+01	9,69E+04
2020	4,71E+06	9,79E+05	1,87E+09	1,84E+02	3,46E+01	7,19E+04	5,91E+06	1,68E+06	2,49E+09	2,16E+02	2,49E+01	7,92E+04
2021	4,18E+06	8,22E+05	1,64E+09	1,53E+02	2,90E+01	5,97E+04	5,31E+06	1,45E+06	2,22E+09	1,80E+02	2,02E+01	6,57E+04
2022	3,70E+06	6,86E+05	1,44E+09	1,28E+02	2,45E+01	5,01E+04	4,76E+06	1,24E+06	1,97E+09	1,51E+02	1,67E+01	5,51E+04
2023	3,27E+06	5,70E+05	1,26E+09	1,08E+02	2,08E+01	4,24E+04	4,27E+06	1,05E+06	1,75E+09	1,28E+02	1,38E+01	4,66E+04
2024	2,89E+06	4,70E+05	1,10E+09	9,19E+01	1,79E+01	3,61E+04	3,99E+06	1,01E+06	1,64E+09	1,15E+02	1,29E+01	4,18E+04
2025	2,54E+06	3,84E+05	9,61E+08	7,80E+01	1,55E+01	3,07E+04	3,92E+06	1,08E+06	1,64E+09	1,08E+02	1,35E+01	4,00E+04
2026	2,23E+06	3,12E+05	8,35E+08	6,65E+01	1,35E+01	2,63E+04	3,67E+06	1,02E+06	1,54E+09	9,76E+01	1,26E+01	3,62E+04
2027	1,95E+06	2,50E+05	7,24E+08	5,70E+01	1,18E+01	2,26E+04	3,34E+06	8,97E+05	1,39E+09	8,62E+01	1,11E+01	3,19E+04
2028	1,70E+06	1,99E+05	6,25E+08	4,89E+01	1,05E+01	1,95E+04	3,04E+06	7,90E+05	1,26E+09	7,72E+01	9,74E+00	2,85E+04
2029	1,48E+06	1,56E+05	5,37E+08	4,18E+01	9,36E+00	1,68E+04	2,77E+06	6,98E+05	1,14E+09	6,95E+01	8,59E+00	2,56E+04

	WGC 15% downtime						WGC + LP2018					
	Gas [Sm3/d]		Total	Condensate [Sm3/d]		Total	Gas [Sm3/d]		Total	Condensate [Sm3/d]		Total
	L-Template	M-Template	[Sm3/year]	L-Template	M-Template	[Sm3/year]	L-Template	M-Template	[Sm3/year]	L-Template	M-Template	[Sm3/year]
2013	7,00E+06	3,00E+06	3,10E+09	5,89E+02	1,02E+02	2,14E+05	7,00E+06	3,00E+06	3,29E+09	5,89E+02	1,02E+02	2,27E+05
2014	7,50E+06	2,50E+06	3,10E+09	5,58E+02	7,17E+01	1,95E+05	7,50E+06	2,50E+06	3,29E+09	5,58E+02	7,17E+01	2,07E+05
2015	8,00E+06	2,00E+06	3,09E+09	5,23E+02	5,01E+01	1,77E+05	8,00E+06	2,00E+06	3,28E+09	5,23E+02	5,01E+01	1,88E+05
2016	7,89E+06	2,11E+06	3,09E+09	4,54E+02	4,71E+01	1,55E+05	7,88E+06	2,12E+06	3,28E+09	4,52E+02	4,72E+01	1,64E+05
2017	7,72E+06	2,28E+06	3,09E+09	3,93E+02	4,57E+01	1,36E+05	7,71E+06	2,29E+06	3,28E+09	3,89E+02	4,55E+01	1,42E+05
2018	7,46E+06	2,32E+06	3,03E+09	3,39E+02	4,15E+01	1,18E+05	7,57E+06	2,43E+06	3,28E+09	3,38E+02	4,27E+01	1,25E+05
2019	6,74E+06	2,01E+06	2,71E+09	2,76E+02	3,28E+01	9,54E+04	7,04E+06	2,25E+06	3,05E+09	2,81E+02	3,56E+01	1,04E+05
2020	6,09E+06	1,75E+06	2,43E+09	2,28E+02	2,64E+01	7,85E+04	6,34E+06	1,95E+06	2,72E+09	2,29E+02	2,82E+01	8,44E+04
2021	5,50E+06	1,52E+06	2,17E+09	1,90E+02	2,15E+01	6,55E+04	5,71E+06	1,69E+06	2,43E+09	1,90E+02	2,30E+01	7,00E+04
2022	4,97E+06	1,31E+06	1,95E+09	1,62E+02	1,79E+01	5,55E+04	5,14E+06	1,46E+06	2,17E+09	1,59E+02	1,92E+01	5,86E+04
2023	4,48E+06	1,13E+06	1,74E+09	1,37E+02	1,50E+01	4,71E+04	4,61E+06	1,25E+06	1,93E+09	1,35E+02	1,59E+01	4,95E+04
2024	4,05E+06	9,77E+05	1,56E+09	1,18E+02	1,26E+01	4,05E+04	4,19E+06	1,10E+06	1,74E+09	1,18E+02	1,37E+01	4,31E+04
2025	3,96E+06	1,04E+06	1,55E+09	1,12E+02	1,32E+01	3,86E+04	3,82E+06	9,77E+05	1,57E+09	1,03E+02	1,21E+01	3,78E+04
2026	3,89E+06	1,10E+06	1,54E+09	1,06E+02	1,37E+01	3,69E+04	3,45E+06	8,50E+05	1,41E+09	9,01E+01	1,05E+01	3,30E+04
2027	3,55E+06	9,74E+05	1,40E+09	9,33E+01	1,20E+01	3,26E+04	3,14E+06	7,50E+05	1,28E+09	8,03E+01	9,24E+00	2,94E+04
2028	3,24E+06	8,62E+05	1,27E+09	8,33E+01	1,06E+01	2,91E+04	2,84E+06	6,50E+05	1,15E+09	7,18E+01	7,99E+00	2,62E+04
2029	2,97E+06	7,65E+05	1,16E+09	7,53E+01	9,42E+00	2,62E+04	2,60E+06	5,80E+05	1,05E+09	6,49E+01	7,12E+00	2,36E+04

Appendix E: Economical calculations

WGC base case

Calendar Year	CAPEX	Increment. Gas Prod. [Sm3]	Increment. Condensate Prod. [bbl]	Sales Income Gas	Sales Income Condensate	OPEX	Depreciation	Losses Carried Forward	Ordinary Tax Base	Uplift	Special Tax Base	Ordinary Tax 28%	Special Tax 50%	Cash Flow	PV of CF	NPV
2013	-600					-2,7								-602,7	-602,7	-602,7
2014	-1200					-2,9								-1202,9	-1113,8	-1716,5
2015	-1200					-31,0	-500,0		-531,0		-531,0	148,7	265,5	-816,8	-700,3	-2416,8
2016		1,63E+08	3,18E+04	375,4	21,0	-35,1	-500,0	-36,6	-175,3		-175,3	49,1	87,7	498,0	395,3	-2021,4
2017		5,41E+08	8,96E+04	1243,4	59,1	-37,5	-500,0		765,1	-75,0	840,1	-214,2	-420,0	630,8	463,7	-1557,7
2018		7,34E+08	9,61E+04	1689,2	63,4	-52,1	-500,0		1200,5	-75,0	1275,5	-336,1	-637,8	726,6	494,5	-1063,2
2019		6,75E+08	6,15E+04	1553,3	40,6	-33,7	-500,0		1060,3	-75,0	1135,3	-296,9	-567,6	695,8	438,4	-624,8
2020		6,27E+08	4,63E+04	1442,0	30,6	-31,4	-500,0		941,2	-75,0	1016,2	-263,5	-508,1	669,6	390,7	-234,1
2021		5,80E+08	3,82E+04	1333,5	25,2	-45,9			1312,7		1312,7	-367,6	-656,4	288,8	156,0	-78,1
2022		5,30E+08	3,14E+04	1219,6	20,7	-30,7			1209,7		1209,7	-338,7	-604,8	266,1	133,1	55,1
2023		4,88E+08	2,59E+04	1121,7	17,1	-30,2			1108,6		1108,6	-310,4	-554,3	243,9	113,0	168,0
2024		5,40E+08	3,63E+04	1242,1	24,0	-41,8			1224,3		1224,3	-342,8	-612,1	269,3	115,5	283,5
2025		6,81E+08	5,83E+04	1567,4	38,5	-26,8			1579,1		1579,1	-442,2	-789,6	347,4	138,0	421,5
2026		7,05E+08	6,24E+04	1622,2	41,2	-26,7			1636,7		1636,7	-458,3	-818,4	360,1	132,4	553,9
2027		6,66E+08	5,87E+04	1532,7	38,8	-41,2			1530,3		1530,3	-428,5	-765,1	336,7	114,6	668,5
2028		6,32E+08	5,70E+04	1453,4	37,6	-26,4			1464,6		1464,6	-410,1	-732,3	322,2	101,6	770,1
2029		6,01E+08	5,55E+04	1381,9	36,7	-26,6			1391,9		1391,9	-389,7	-696,0	306,2	89,4	859,5

WGC increased downtime

Calendar Year	CAPEX	Increment. Gas Prod. [Sm3]	Increment. Condensate Prod. [bbl]	Sales Income Gas	Sales Income Condensate	OPEX	Depreciation	Losses Carried Forward	Ordinary Tax Base	Uplift	Special Tax Base	Ordinary Tax 28%	Special Tax 50%	Cash Flow	PV of CF	NPV
2013	-600					-2,7								-602,7	-602,7	-602,7
2014	-1200					-2,9								-1202,9	-1113,8	-1716,5
2015	-1200					-31,0	-500,0		-531,0		-531,0	148,7	265,5	-816,8	-700,3	-2416,8
2016		-2,68E+07	-2,41E+04	-61,7	-15,9	-35,1	-500,0		-612,7		-612,7	171,6	306,3	365,2	289,9	-2126,8
2017		3,51E+08	4,77E+04	806,4	31,5	-37,5	-500,0	-114,2	186,2	-75,0	261,2	-52,1	-130,6	617,6	454,0	-1672,9
2018		6,12E+08	7,76E+04	1408,7	51,2	-52,1	-500,0		907,8	-75,0	982,8	-254,2	-491,4	662,2	450,7	-1222,2
2019		5,83E+08	5,20E+04	1341,0	34,3	-33,7	-500,0		841,6	-75,0	916,6	-235,7	-458,3	647,7	408,1	-814,0
2020		5,59E+08	4,20E+04	1284,6	27,7	-31,4	-500,0		780,9	-75,0	855,9	-218,7	-428,0	634,3	370,1	-443,9
2021		5,30E+08	3,66E+04	1219,4	24,2	-45,9			1197,6		1197,6	-335,3	-598,8	263,5	142,3	-301,6
2022		5,06E+08	3,40E+04	1163,4	22,4	-30,7			1155,1		1155,1	-323,4	-577,6	254,1	127,1	-174,5
2023		4,77E+08	2,92E+04	1096,0	19,3	-30,2			1085,0		1085,0	-303,8	-542,5	238,7	110,6	-63,9
2024		4,55E+08	2,81E+04	1045,4	18,6	-41,8			1022,2		1022,2	-286,2	-511,1	224,9	96,4	32,6
2025		5,86E+08	4,96E+04	1348,7	32,7	-26,8			1354,7		1354,7	-379,3	-677,3	298,0	118,4	150,9
2026		7,09E+08	6,71E+04	1630,9	44,3	-26,7			1648,5		1648,5	-461,6	-824,3	362,7	133,4	284,3
2027		6,76E+08	6,26E+04	1554,5	41,3	-41,2			1554,7		1554,7	-435,3	-777,3	342,0	116,4	400,7
2028		6,46E+08	6,02E+04	1485,4	39,7	-26,4			1498,7		1498,7	-419,6	-749,4	329,7	103,9	504,7
2029		6,18E+08	5,91E+04	1421,9	39,0	-26,6			1434,2		1434,2	-401,6	-717,1	315,5	92,1	596,8

WGC LP 2018

Calendar Year	CAPEX	Increment. Gas Prod. [Sm3]	Increment. Condensate Prod. [bbl]	Sales Income Gas	Sales Income Condensate	OPEX	Depreciation	Losses Carried Forward	Ordinary Tax Base	Uplift	Special Tax Base	Ordinary Tax 28%	Special Tax 50%	Cash Flow	PV of CF	NPV
2013	-600					-2,7								-602,7	-602,7	-602,7
2014	-1200					-2,9								-1202,9	-1113,8	-1716,5
2015	-1200					-31,0	-500,0		-531,0		-531,0	148,7	265,5	-816,8	-700,3	-2416,8
2016		1,63E+08	3,18E+04	375,4	21,0	-35,1	-500,0	-36,6	-175,3		-175,3	49,1	87,7	498,0	395,3	-2021,4
2017		5,41E+08	8,96E+04	1243,4	59,1	-37,5	-666,7		598,4	-75,0	673,4	-167,5	-336,7	760,8	559,2	-1462,2
2018	-1000	8,71E+08	1,23E+05	2003,0	81,5	-52,1	-666,7		1365,7	-75,0	1440,7	-382,4	-720,4	-70,4	-47,9	-1510,1
2019		9,27E+08	1,04E+05	2131,3	68,9	-33,7	-666,7		1500,0	-112,5	1612,5	-420,0	-806,2	940,4	592,6	-917,5
2020		8,54E+08	7,91E+04	1964,2	52,2	-31,4	-666,7		1318,3	-112,5	1430,8	-369,1	-715,4	900,5	525,4	-392,1
2021		7,88E+08	6,47E+04	1812,6	42,7	-45,9	-166,7		1642,7	-37,5	1680,2	-460,0	-840,1	509,3	275,2	-116,9
2022		7,30E+08	5,38E+04	1678,9	35,5	-30,7	-166,7		1517,1	-37,5	1554,6	-424,8	-777,3	481,7	241,0	124,1
2023		6,64E+08	4,45E+04	1527,9	29,3	-30,2			1527,0		1527,0	-427,6	-763,5	335,9	155,6	279,7
2024		6,35E+08	4,41E+04	1460,2	29,1	-41,8			1447,4		1447,4	-405,3	-723,7	318,4	136,6	416,2
2025		6,13E+08	4,44E+04	1410,9	29,3	-26,8			1413,5		1413,5	-395,8	-706,7	311,0	123,5	539,7
2026		5,78E+08	4,25E+04	1328,3	28,0	-26,7			1329,7		1329,7	-372,3	-664,8	292,5	107,6	647,3
2027		5,54E+08	4,27E+04	1274,6	28,2	-41,2			1261,7		1261,7	-353,3	-630,8	277,6	94,5	741,8
2028		5,22E+08	4,20E+04	1201,2	27,7	-26,4			1202,6		1202,6	-336,7	-601,3	264,6	83,4	825,2
2029		5,08E+08	4,30E+04	1168,3	28,4	-26,6			1170,0		1170,0	-327,6	-585,0	257,4	75,1	900,3