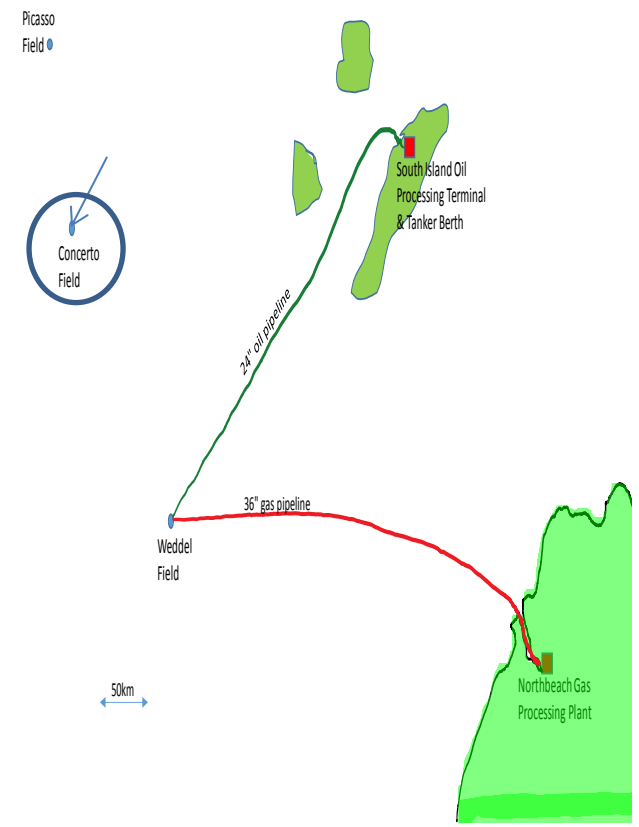
Table of Contents

1 Introduction

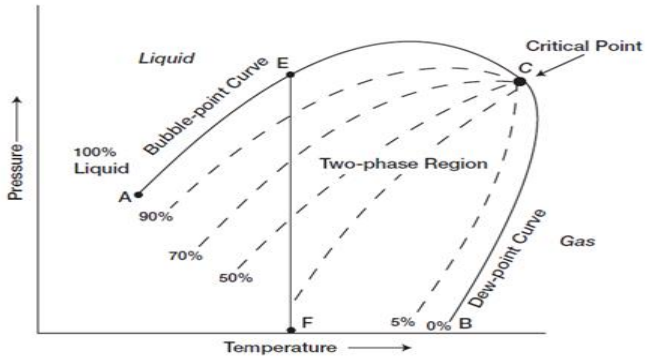
Basic Facts about Concerto Field



- Location: 350 Kilometres from the nearest landfall (South Island)
- Depth of water: 600 metres, on shelf slope shallowing rapidly to the east
- Climate: Temperate, harsh met/ocean conditions susceptible to extreme wind, wave and sub-marine currents
- Estimated recoverable oil: 300 MMBO (300 million barrels oil)
- Expected peak oil production rate: 120mbopd (120 thousand barrels per day)
- Expected peak gas production rate: 30mmscfd (30 million standard cubic feet per day)
- Initial Gas Oil Ratio: 250scf/bbl (250 standard cubic feet per barrel) at export conditions
- Bubble-point pressure of oil: 4,300 psia (pounds per square inch absolute)
- Crude quality: medium, 24°API gravity

With the above given information about concerto field, the Reservoir is a Black Oil Reservoir [1] located in a harsh Deep Water Environment.

Black Oil Reservoir Properties [1]



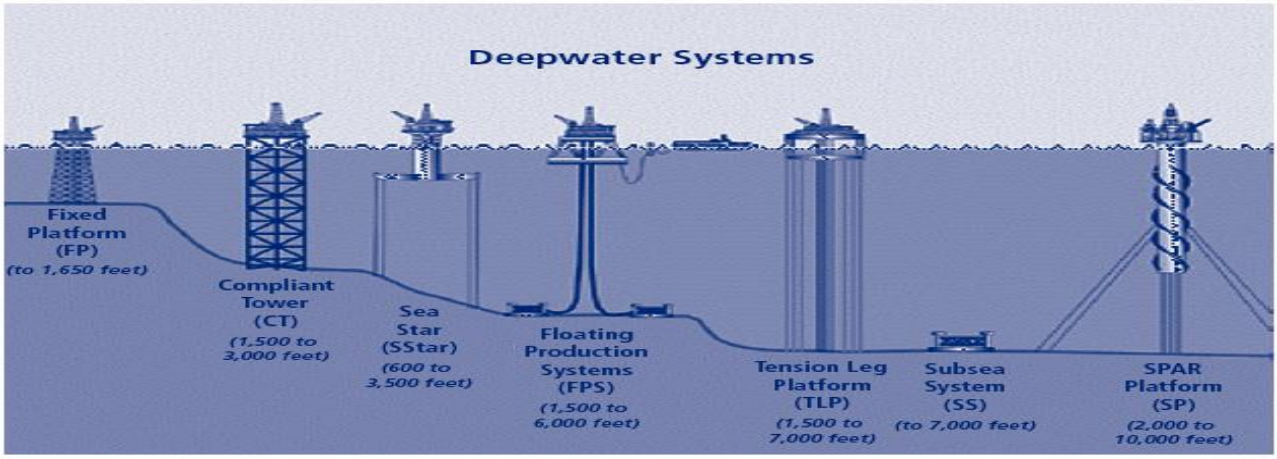
- Quality lines are approximately equally spaced
- Gas-Oil ratios between 200–700 SCF/STB
- Oil gravities of 15 to 40° API
- Color is brown to dark green
- C_7^+ composition > 30%
- Reservoir temperature less than 250 °F

Based on Classifications of fields as Commercial, Uncommercial and Marginal, Concerto field is a Marginal field as its estimated recoverable oil falls between <50 to 500 MMBO which is typical of marginal oil fields [2], and also as conventional and tested technology for developing fields in harsh

environment cannot be used [2] for the optimum recovery of Concerto hydrocarbons, largely due to depth of water (600m). The fixed (Steel Jacket) platform which is a known technology for developing fields in harsh environment [2] cannot be used for concerto field due to the following reasons below and hence my classification of concerto field as marginal.

Steel Jacket Structure [2,3]

	➢ Limited to maximum of 500m water depths. ➢ Long Construction period, costly to construct due to its huge size, though can carry large topside weight. Often leads to excessive delay in project cash flow ➢ Best suited for large field developments ➢ Decommissioning can be uneconomical and complicated



Deep Water Structures [1]

Sequel to this, Concerto field will be developed with Marginal Field Technology which is a combination of Subsea systems and Floating Production/Supporting Structures which possess attractive characteristics as:

- ✓ Fast development period, mobility and re-use options [2].

The Subsea systems in Marginal Field Technology include; Riser, subsea equipment, Storage system, offshore offloading system, processing facilities and Export system [2]. These components together with the various suitable Deepwater production supports shall be considered and critically evaluated and then based largely on technical factors and to a lesser extent on economics, a suitable Integrated System will be recommended to Solar Oil for Concerto field Development.

2 Deepwater Production Supports/Structures

Jack-ups

- Usually for drilling but convertible to production support with draw-backs on water depth and topside weight [2].

Jack-up Structure [2]

	**MERITS** • A known technology with cheap hiring rates • No moorings required • Cheap abandonment cost and can be used for drilling after.	**DEMERITS** • Huge limitations on water depth (<75m) and topside weight • Sensitive to soil conditions and topography due to leg support • Lack of Storage capacity • May not be suitable for long term usage

Semi-submersibles

- ✓ Can be converted to a production platform by addition of appropriate topside facilities

Semi-submersible Structure [2]

	**Merits** • Suitable for harsh and severe environments • Low abandonment cost • Can perform simultaneous drilling • Can operate in Deepwater (60-3000m)	**Demerits** • Not easy to be converted to a supporting platform • No storage capacity • Requires standby shuttle tanker • Limitations on number of wells it can cover (4-40)

Barge Based Systems

- A monohull structure which must be towed to the desired location [2]

Barge Based systems [2]

	**Merits** • Large deck capacity and can carry reasonable topside weight • Storage capacity • Convertible at a reasonable cost	**Demerits** • Requires mooring in order to weathervane • Water depth limitations(<150m) • No drilling capability

Tension Leg Platforms

- Semi-submersible shaped, its natural buoyancy aids in the vertical stability of the structure while making horizontal movement [2]

Tension Leg Platforms [2-4]

	**Merits** • Cheap in deep water operations with excellent vertical stability due to its tethers • Minimal horizontal motions • Workover capability	**Demerits** • Only useable in water depth of more than 500m • Not possible to convert semi-submersible to a TLP • Still in early development stages

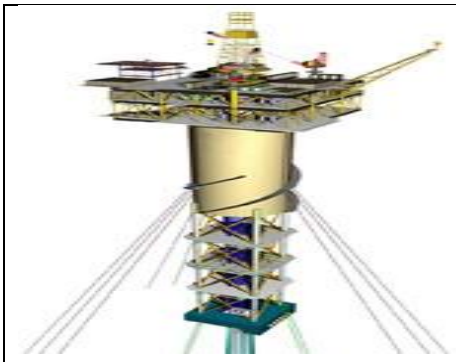
Floating Production Drilling Storage and Offloading vessel (FPDSO)

- ❖ Cost effective and a new concept of offshore platform that integrates the known FPSO with a drilling unit [5]

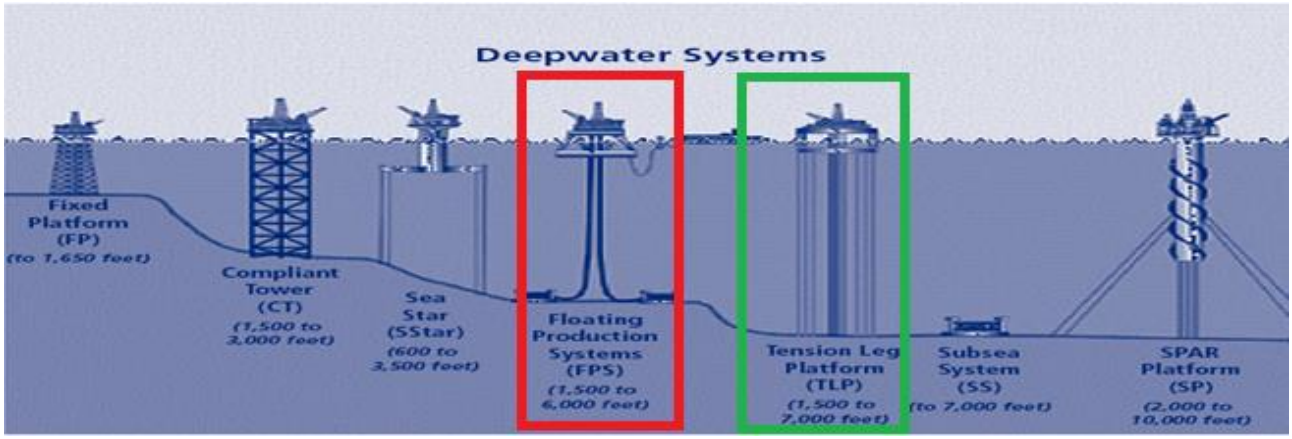
Floating Production Drilling Storage and Offloading Vessel [3-6]

	**Merits** • Attractive for Deepwater commercial and marginal fields • Useful for early production systems • Excellent storage capacity with drilling capability • Minimal equipment for decommissioning	**Demerits** • Earlier designs could result to environmental damage anytime the vessel disconnects itself from the subsea manifold • Sometimes have issues with weather condition

Spar [1,4]

	**Merits** • Good offshore dynamic and greater water depth capabilities	**Demerits** • Limited storage capacity and suitable for only greater water depths of over 600m • Economical only in Deepwater commercial fields

Having critically evaluated most existing and proven technologies for offshore production support, based on technical factors like ability to be deployed optimally in a marginal harsh remote offshore Deepwater fields, storage and offloading capacities, I've identified two optimal and viable production support technologies which can be used in concerto field development.
The two most viable platforms that can be used are **TENSION LEG PLATFORM (TLP)** and **FLOATING PRODUCTION DRILLING STORAGE & OFFLOADING VESSEL (FPDSO).**



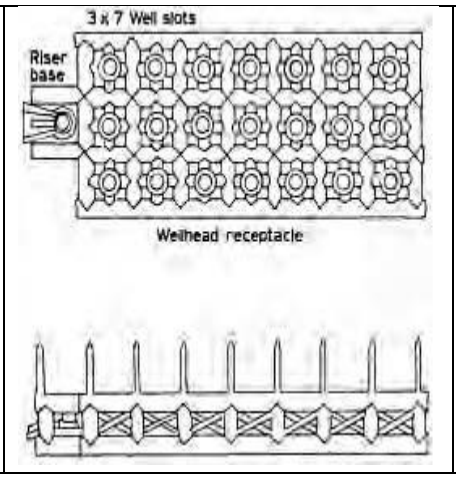
Before further comparisons and evaluation of these two platforms, it is pertinent to briefly explain the other Subsea equipment that will be integrated with both of the platforms for optimum development and production of concerto field.

2.1 Subsea System

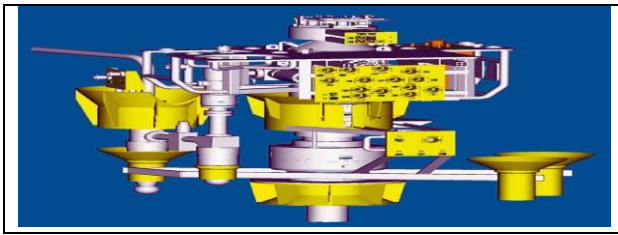
Subsea Production Equipment

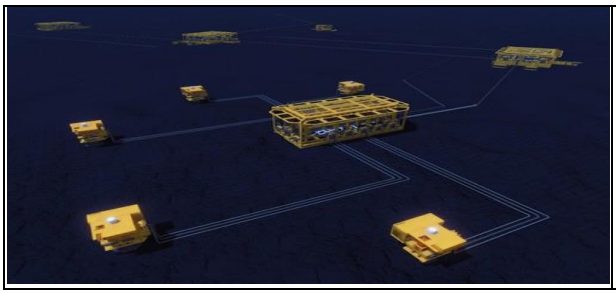
- An integrated system containing Template, Subsea Xmas tree, Manifold and the Control System [2]

Subsea Template [2,7]

		❖ A steel structure constructed to contain and align several wellhead assemblies ❖ Provides a base for well drilling ❖ Can accommodate all existing and future concerto field wells

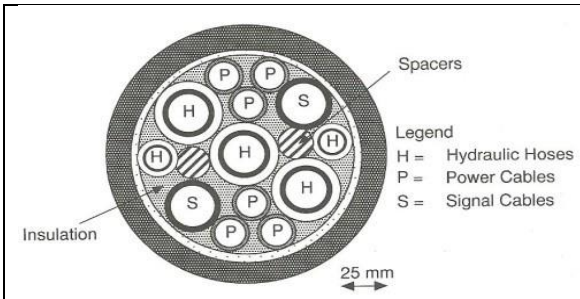
Subsea Xmas Tree [8]

	❖ Basically for the control of fluid flow rate ❖ Contains arrays of pipe and valves and it's positioned on the wellhead

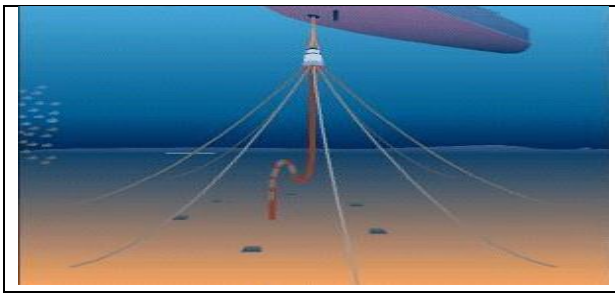
	❖ Interface connecting the production equipment and the riser ❖ Contains several valves, chokes, injectors and acts as a gathering point for subsea pipelines and umbilical

The Subsea Manifold [2,8]

Subsea Control System [2,9]

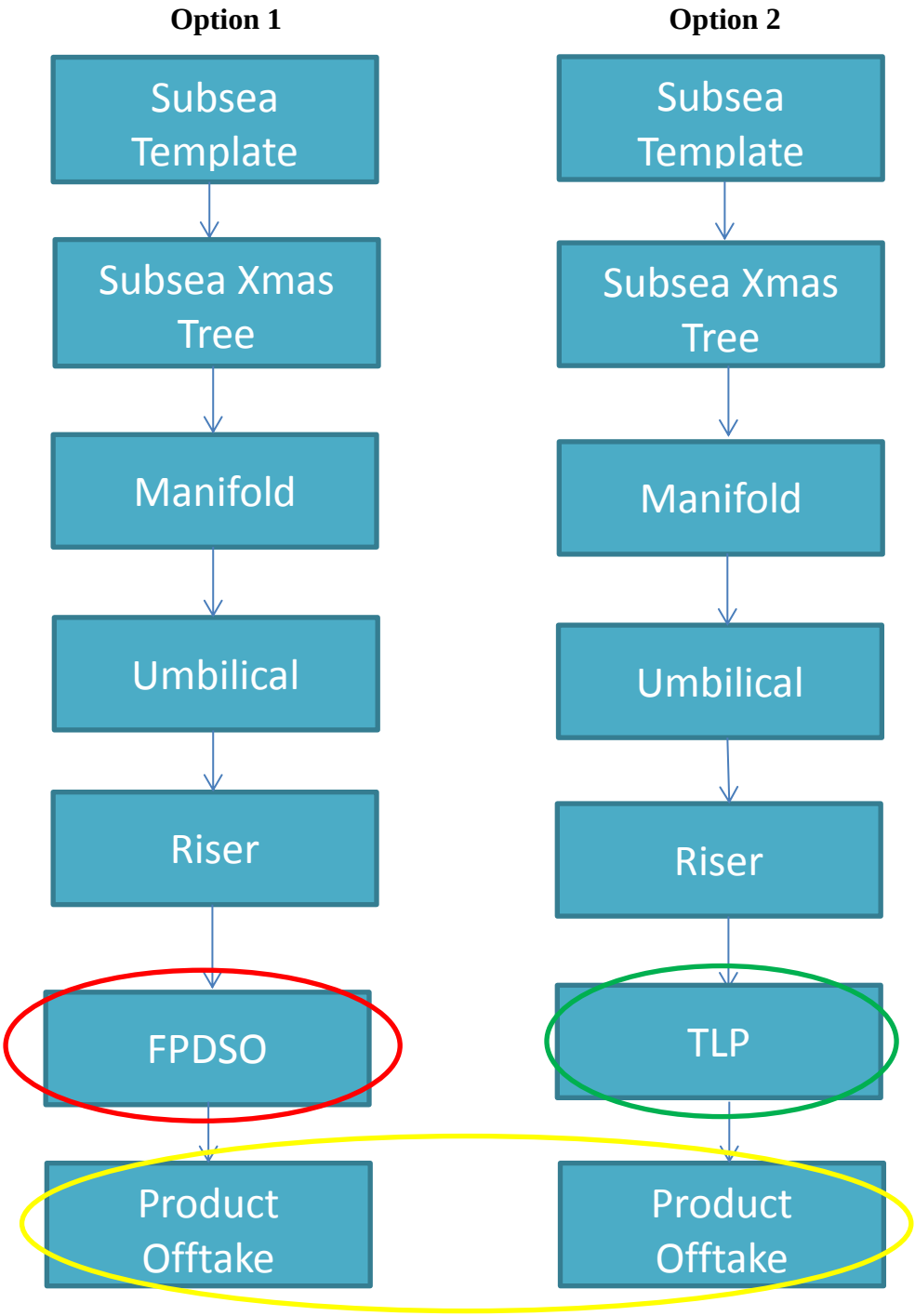
	❖ For controlling subsea equipment via electrical and hydraulic modes ❖ Referred to as electro-hydraulic umbilical ❖ Provides communication between the surface and subsea

Riser system [2,10]

	❖ This is a complex subsea system that connects the subsea manifolds to the topside facilities ❖ The system includes production, drilling workover, wireline and offtake risers.

Other items in offshore development system are the **Storage, Processing**, **Offloading and Transport/Offtake Facilities** [2]**.** The Storage, Processing and Offloading requirements are met by the platform/supporting structures as they are incorporated as topside facilities [2] and are among the selection criteria on which **TLP** and **FPDSO** have been selected over other existing offshore platforms for further evaluation. The Offtake Systems for Oil and Gas will also be critically evaluated based on economics and technical factors in due course.

Having looked at the various systems and structures, the two development concepts for concerto field can be represented in flow diagrams from subsea to the surface as below.



Before preparing a flow schematic for the two development concepts, it is important at this point to evaluate the offshore transport options available for oil and gas and then select appropriate offtake systems based on technical and economic viabilities.

3 Product Offtake

- Transport facilities from production platform to the export point [11].

3.1 Oil Offtake

Two options are available; **Pipeline** and **Shuttle Tanker** [11]

3.1.1 Pipeline

Using pipeline for oil offtake from Concerto field will face many technical challenges and may not be a feasible option based on the following given information:

- The east of Concerto field which leads to where the Oil Refinery is located has shallow banks which are major fishing area. This is a huge challenge as it poses trait of Pipeline Vandalisation which could lead to a major economic loss.
- The distance from Concerto field to the Refinery is 350km. Pipelines are only attractive option for shorter distances [11].

The above challenges are enough to eliminate oil pipeline offtake option but it is still important to look at the economic implication of laying 350km pipeline

Pipeline Size and Unit Cost Estimation [2]

Field reserves (millions of bbl of oil)	*Peak oil flows (b/d)*	*Pipeline internal dia. (in.)*	*Pipeline costs, procurement, installation ($/inch mile)*	*Pipeline costs, procurement, installation ($/mile)*
25	15 000	8.0	140 000	1 120 000
50	20 000	12.0	140 000	1 680 000
150	50 000	18.0	140 000	2 520 000
300	120 000	26.0	140 000	3 640 000
600	170 000	30.0	140 000	4 200 000

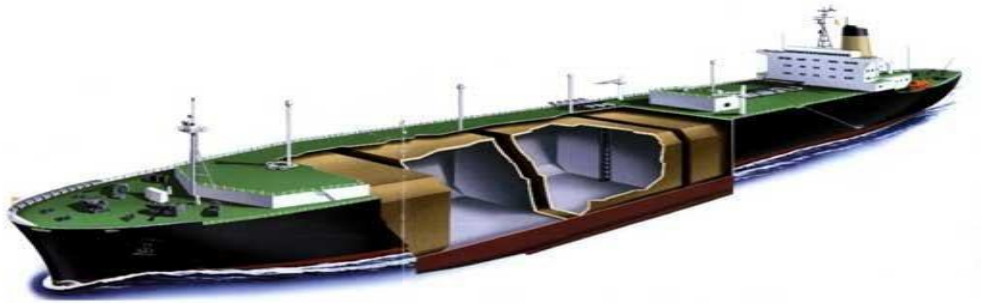
Concerto →

With this estimated cost, it then means that to lay 350km pipeline will cost Solar Oil about **$2bn**.

3.1.2 Shuttle Tanker

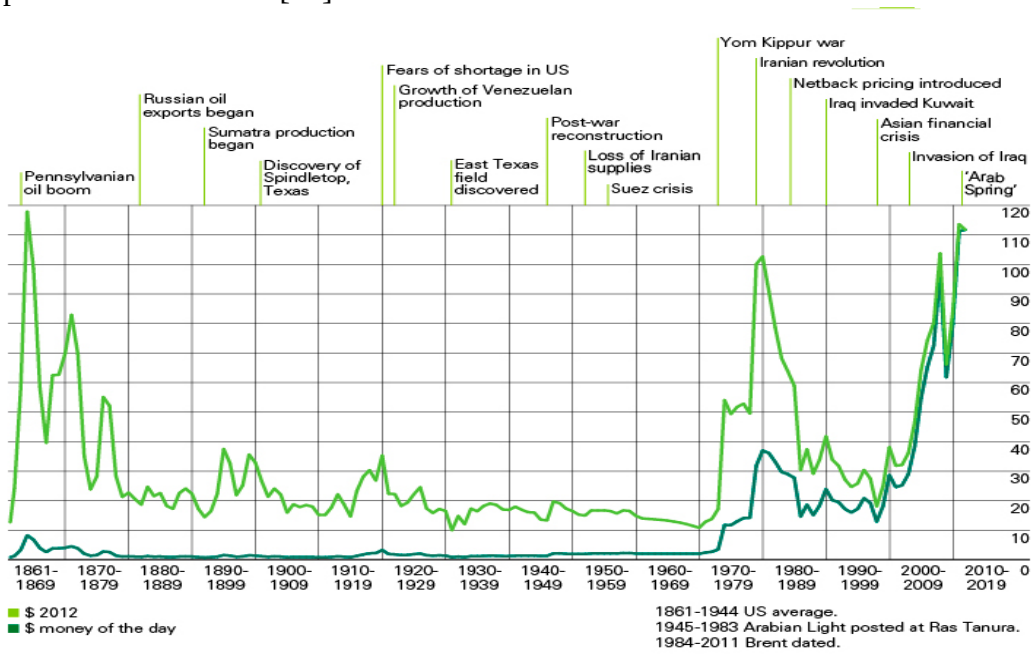
The choice of the size and type of tanker is usually a function of daily production, time to shuttle to and from offloading points and environmental conditions [2].

I advise Solar Oil to refurbish existing tanker say five years old and convert it into a double hulled tanker since the expected peak daily production will be 120,000bbl and this will also prevent oil spills. The cost of doing this is about **$22m** [2,11].



Double-Hulled Tanker [11]

Assuming Oil price remains $111.67 per barrel throughout Concerto Production phase as estimated in BP oil price statistics below [12].



Crude Oil prices 1861-2012 [12]

Then for estimated 300MMBO, about $33.5bn will be generated through oil sales and using Tanker offtake system would be much more attractive than pipeline both technically and economically, hence I recommend that Solar Oil should utilise Shuttle Tanker for its Oil offtake.

3.2 Gas Offtake

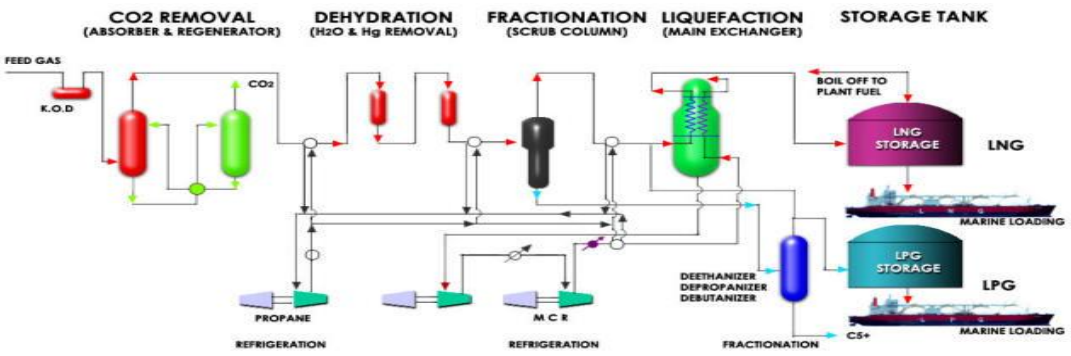
There are two options for offshore gas transportation: **LNG Ships** and **Pipelines** [11]

3.2.1 LNG Ships

LNG Ship [11]

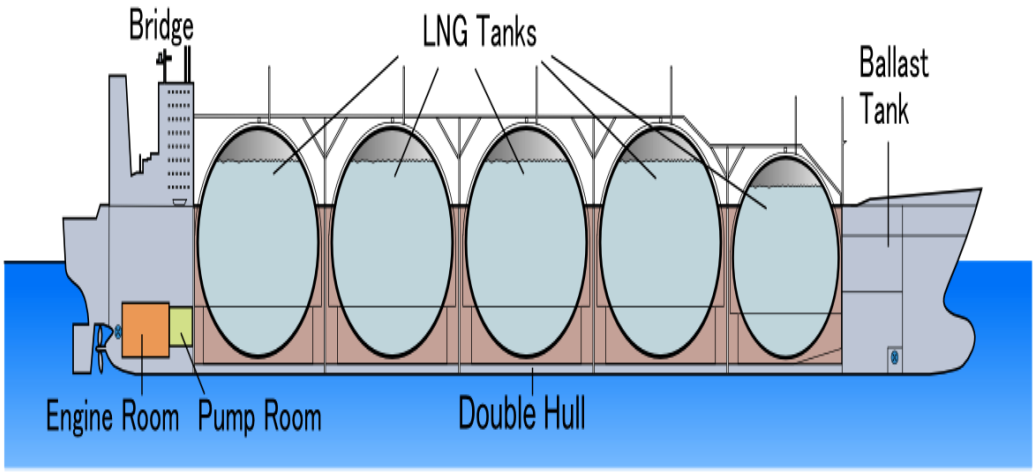
I won't advise Solar Oil to use LNG ship for Concerto field gas offtake because of the following reasons

- ✓ The gas must be in a liquid state, this has to be achieved by a Liquefaction process which involves " a set of thermodynamic Refrigenation operations starting from compression to supercritical conditions followed by constant-pressure cooling and isenthalpic expansion" [13]



LNG Liquefaction Process [11]

In addition to the expensive liquefaction process, the Ship tanks require intermediate storage facilities [13].



LNG Vacuum Insulated Tanks [11]

This will be quite uneconomical for a marginal field.

- ✓ Normally not all the gas produced will be sold, some portions will be used as fuel gas for power generations, some will be flared [2] and most importantly it has been said that Gas lift may be required in the future, assuming the produced gas after flaring and power generation is not enough for the gas injection, how would Concerto field get more gas? The only option will be through pipeline. It would be disastrous economically if plans aren't put in place now for an alternative source of gas for gas injection requirement.

Sequel to this, I eliminate the option of LNG ship for gas offtake.

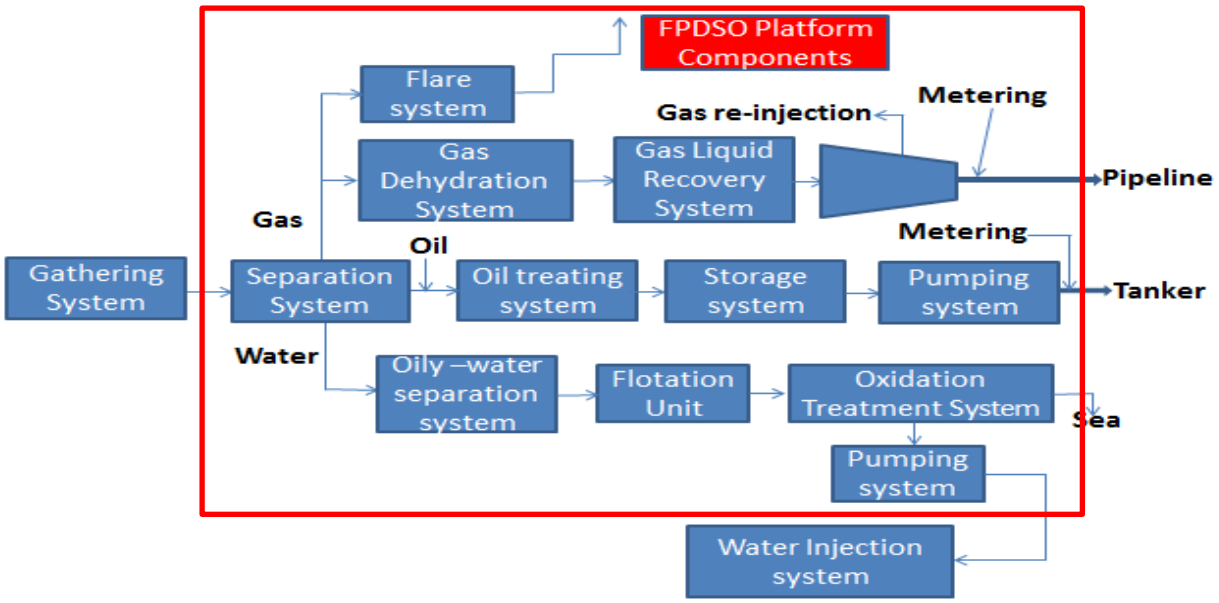
3.2.2 Gas Pipeline

With all the limitations and challenges over the use of LNG ships, the use of pipeline for gas offtake is the most feasible as it will still serve as a means of bringing gas into the field if the need for more gas for EOR arises.

At this juncture, I can now look at the process flow schematic for both development concepts to be considered.

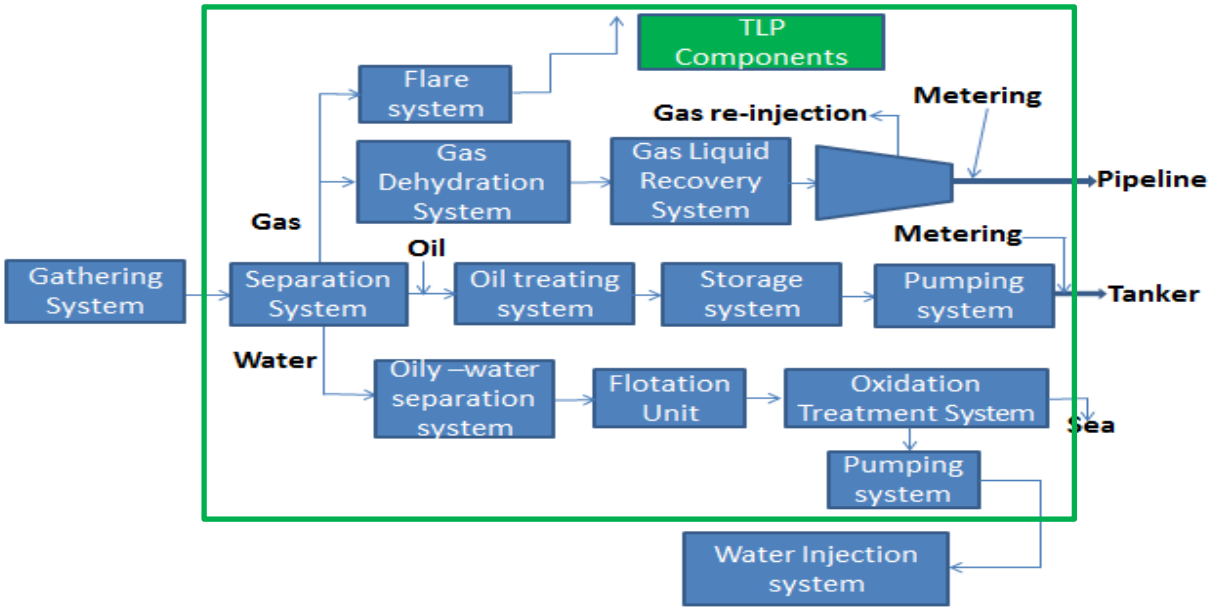
4 Offshore Platform Process flow Schematic

4.1 OPTION ONE- FPDSO



Flow Diagram of possible systems on an FPDSO platform [2]

4.2 OPTION 2- TLP



Flow Diagram of possible systems on a Tension Leg Platform [2]

4.3 Offshore Platform Process Module

The major **components** for both development concepts are:

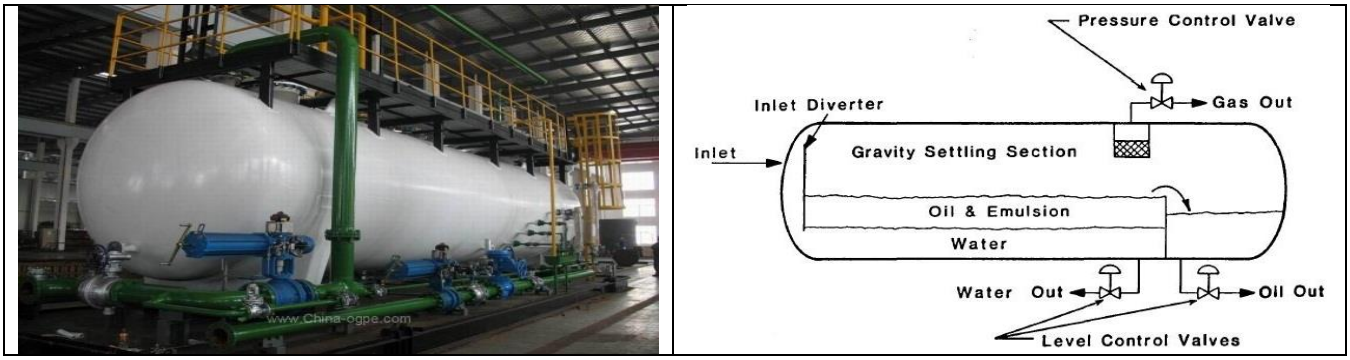
- ✓ Separator Vessel, Heater Treater, Centrifugal Pump, Molecular Sieves, Adsorption Bed, Axial Compressor, Displacement Meters, Water Treatment system (CTour Process with mixer and hydrocyclone. CFU, Aquapurge).

Separator Vessel

- To separate the well fluids into three phases [2]. The mode of separation is density differences between gas, oil and water [2,14]. It also removes solids which should be taken out of the separator by periodic jet wash [14].

It is chosen as it is a matured technology for multi-phase separation [14].

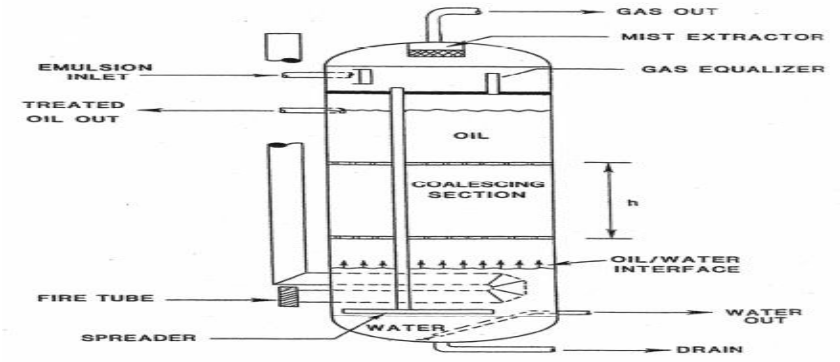
Separator Vessel [14,15]



Heater Treater

- To increase water and oil separation by physically breaking the emulsion via heating [15].

The heater treater is one the cheapest physical means of breaking emulsion.

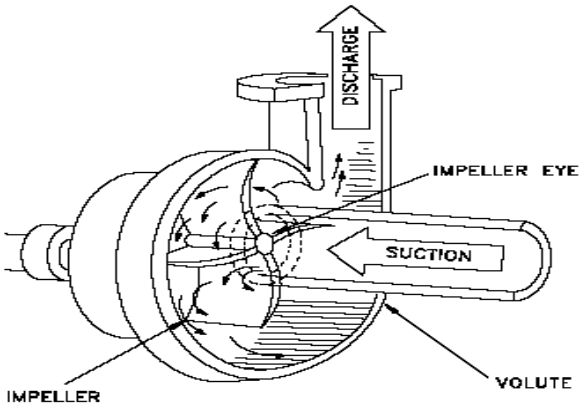


Heater Treater [15]

Centrifugal Pump

- To accelerate oil flow towards the export system by pressurizing the oil. Will still be used to pump water towards reinjection system.

Centrifugal pump is the best as it is continuous, generates high flow and lower head loss due to friction than a reciprocating pump [15].

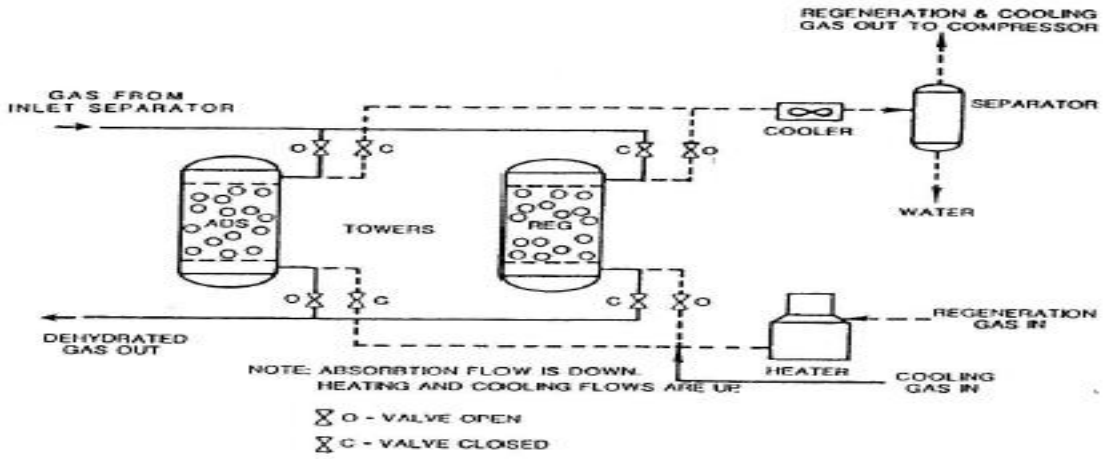


Centrifugal Pump [15]

Molecular Sieves

- A solid desiccant with high surface to volume ratio used for adsorbing water from gases.

Preferred to glycol due to its ability to work at a variety of flow rates and can generate lower dew points than glycol [15].



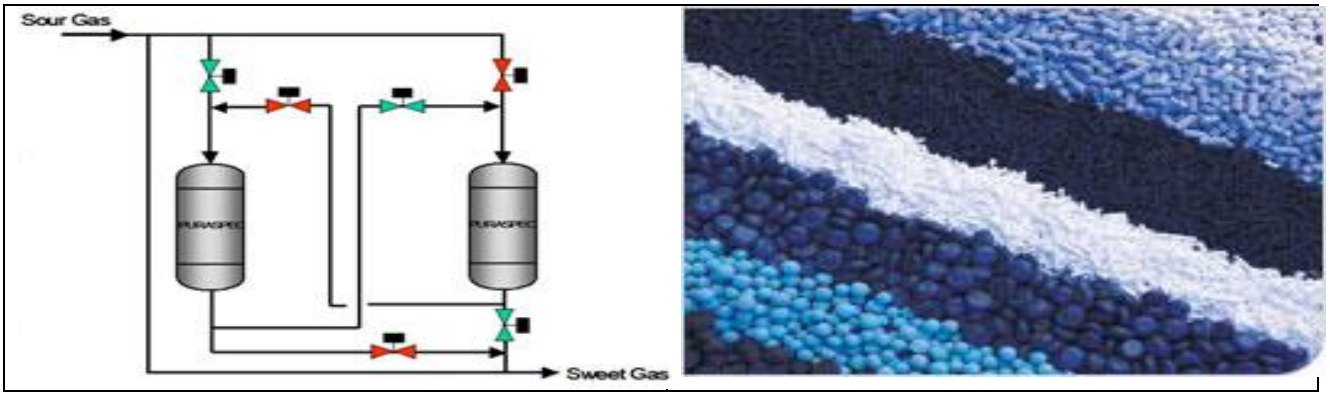
Solid Bed Dehydration Process [15]

Adsorption Beds

- For gas sweetening by removal of CO_2, H_2S and mercury [15].

The use of amine will need stripping and replacement of degraded amine solvents, this leads to plant efficiency reduction and high running cost [13]. Membrane technology isn't matured yet. So Adsorption bed will be used for gas sweetening.

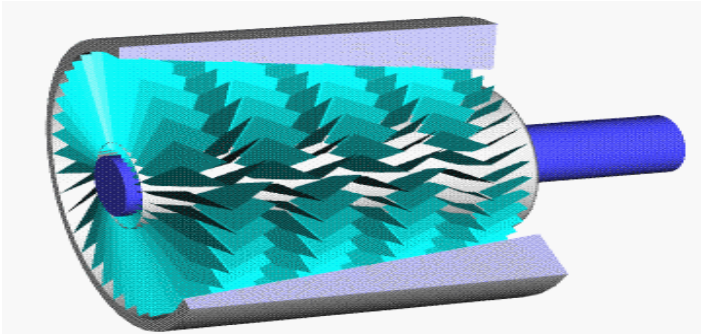
Adsorption Beds [15]



Axial Compressor

- A mechanical device for increasing gas pressure by reducing its volume. Increases gas flow rate towards the export system and for reinjection

Axial Compressor will be used because of its compact design and generates higher gas flow rate than centrifugal and reciprocating compressors.

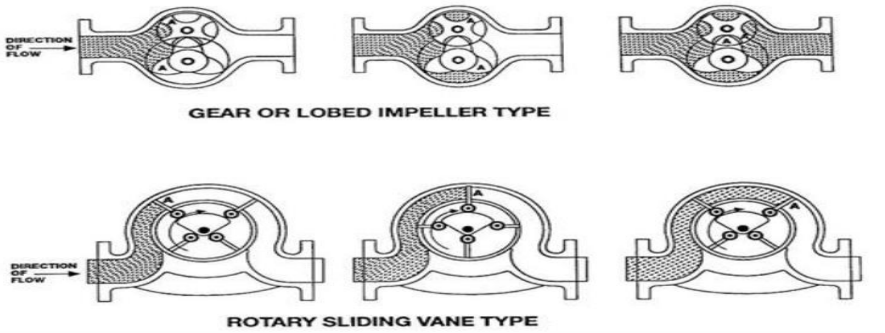


Axial Compressor [15]

Displacement Meters

- To measure the volumetric flow rate of oil and gas leaving the production facility after processing

Displacement meter is chosen because it is the only matured technology for volume measurement with excellent repeatability and high turndown [16].



Displacement Meters [16]

Produced Water treatment System

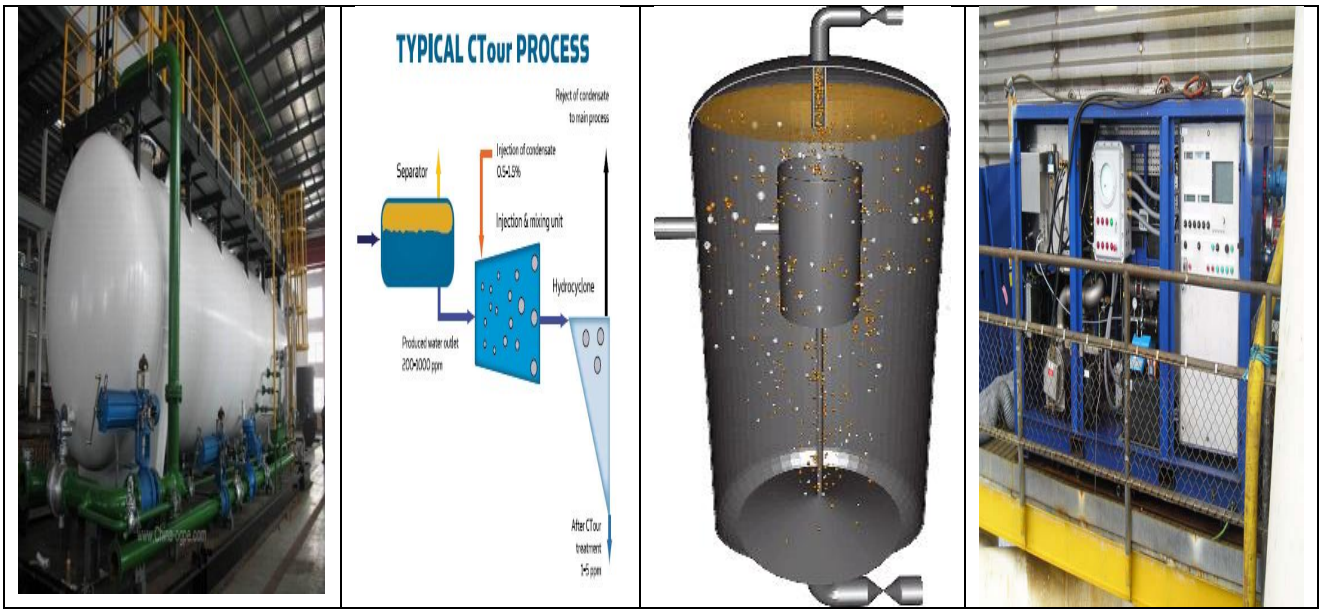
Concerto field produced water should be polished and treated adequately prior to sea disposal and water reinjection so as to meet environmental regulations and avoid flow assurance problems like scaling. To achieve this, the water will be treated with a combination of treatment methods; Density separation, Coalescing and Chemical treatment.

The density separation will be done using a **separator vessel**, from the separator vessel the water will enter a **mixer** where NGL will be injected and mixed with the water in order to lighten the oil. This will improve the efficiency of the subsequent treatment in **hydrocyclone.** This is a Coalescing method of water treatment and the process is known as a **CTour process** [14].

More Coalescing of the oil in water is achieved using the **Compact Floatation Unit**. This device accelerates gravity separation of small droplets [14].

The Final Water treatment will be done using **Aquapurge** to make sure the produced water is free from bacteria and all hazardous substances prior to disposal and re-injection. This is done by Ultra Violet radiation [14].

Produced Water treatment components [14]



5 Technical and Economic Analysis of the two Development Concepts

FPDSO and TLP comparison [2-4,6]

FPDSO	TLP
	
Construction cost $125m	Construction cost $100m
Can exploit several different marginal fields without its drilling unit on	minimal motions
Ease of decommissioning	Large components removal makes decommissioning costly
Widely used as early production systems in Deepwater	Rarely used, still in early development stages
Operations affected by weather conditions	Good resistance to harsh weather due to its tethered structure
With its drilling unit can simultaneously drill wells without production interruption	No drilling capacity
Suitable for varying water depths	Only suitable for water depths above 500m

With the analysis above and the factor below, I strongly recommend Solar Oil to use **FPDSO** platform in developing Concerto field

- It is said that a further two production wells may be required in the future, the best platform to achieve this with minimal production interruption is **FPDSO** [5]

FPDSO Vessel [6]

6 Produced Water treatment and OSPAR Regulations

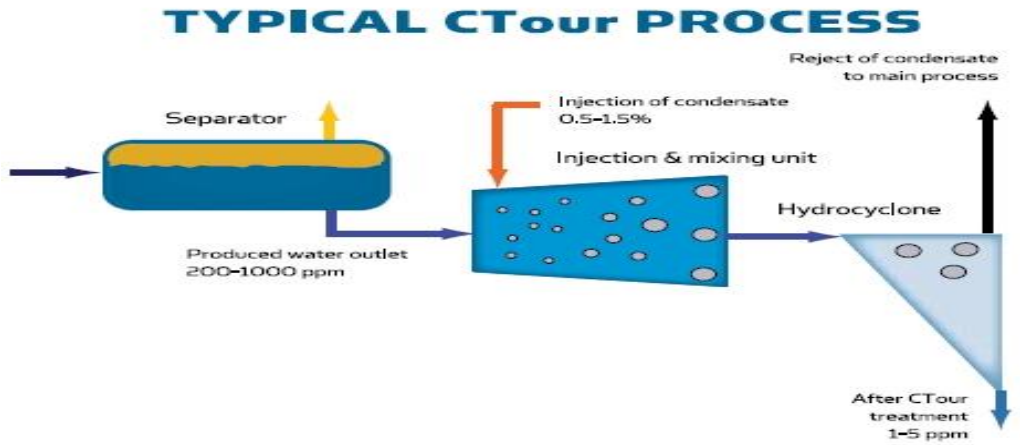
6.1 Current OSPAR regulations

- OSPAR recommendation 2001/1 focuses on the application of Best Available Technique and Best Environmental Practice to ensure that the concentration of oil in produced water prior to sea disposal is less than 30mg dispersed oil per litre of produced water [17,18]

All necessary components needed to meet this requirement are already in place in Concerto field platform.

The process will involve;

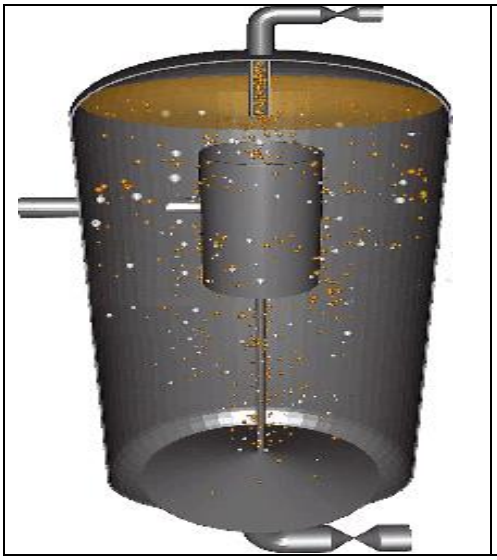
- ✓ The use of **separator vessel** to remove solids in water which (solid) would be removed periodically by jet wash [14]
- ✓ Coalescing using **CTour** process which involves injecting and mixing NGL with the produced water to lighten oil and improve subsequent separation. This process uses a **mixer** and **hydrocyclone**. CTour process is highly efficient, reduces the Oil in Water concentration from 200-1000mg/L to 1-5mg/L [14].



CTour Process [14]

Only CTour process is enough to the meet the current OSPAR regulation stated above but yet other treatment methods with appropriate devices are still on the platform. **Compact Floatation Unit** is one of them. This will help improve Oil in Water separation the more.

Compact Flotation Unit [14]

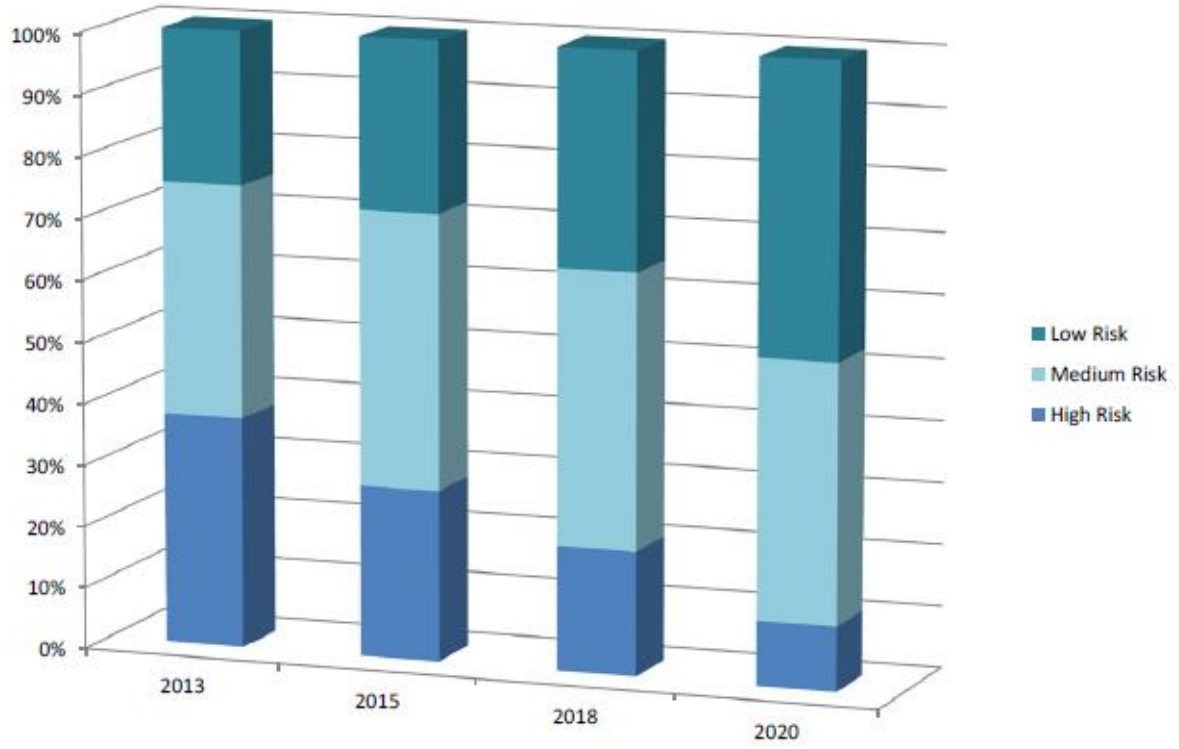


- ❖ The rise of gas bubbles through the vessel will cause oil droplets to rise and coalesce
- ❖ Accelerates gravity separation especially for small droplets
- ❖ Removes solid in water which would be removed from the vessel by periodic flushing

6.2 OSPAR Risk Based Approach Recommendation

- ✓ Adopted in 2012, prioritises mitigation actions on those discharges and substances that pose the greatest risk to the environment [18]

The goal is "cessation of discharges of hazardous substances by the year 2020" [18]. All substances in produced water will be analysed and then be classified as low, medium or high risk components. Best Available Techniques and Best Environmental Practise will be required to keep all the high risk components to the minimum [17,18].



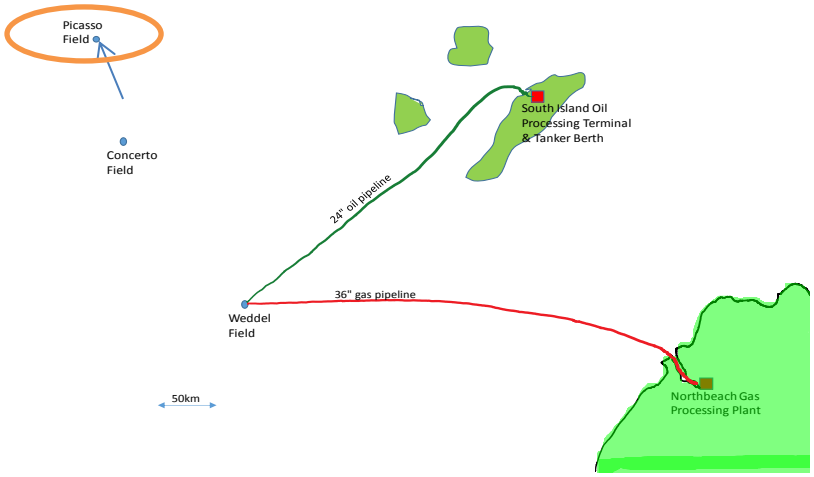
Theoretical Illustration of how the implementation of a risk-based approach would be expected to result in changes in the proportions of low, medium and high risk components of discharges [18]

In addition to the treatment processes explained above to meet the current OSPAR regulation, the risk-based criteria will be met by Chemical/Oxidation treatment process using **Aquapurge**. This device will clear all hazardous substances left in the produced water through Ultra-Violet radiation [14].

Aquapurge [14]

7 Opportunities to share facilities with other fields

7.1 Picasso Field

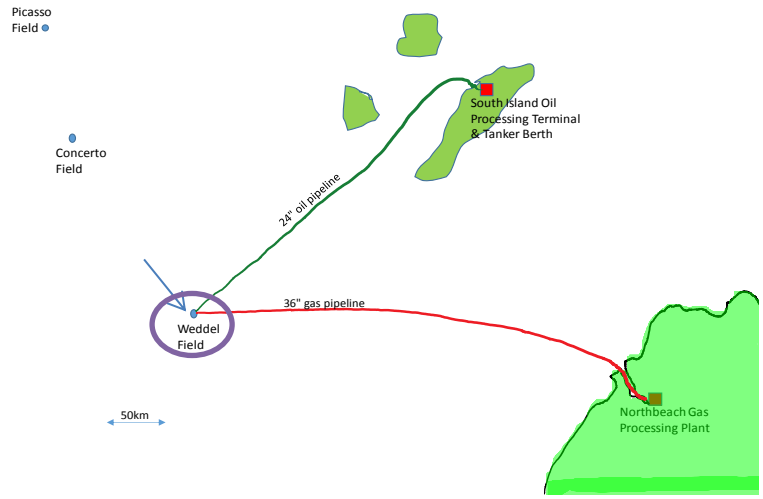


- Located north of Concerto field, served by shuttle tankers for oil offtake, all gas is flared.

With this information, the only facility Concerto field can consider sharing with Picasso field is the FPSO vessel. It is true that FPSO vessel can exploit two marginal fields at the same time [4] but considering the fact that Concerto field may require a further two production wells in the future, sharing Picasso field FPSO vessel may not be technically feasible because we do not know the distance between the fields, mobility of FPSO vessel reduces drastically when converted to FPDSO because of the weight of the drilling unit [5].

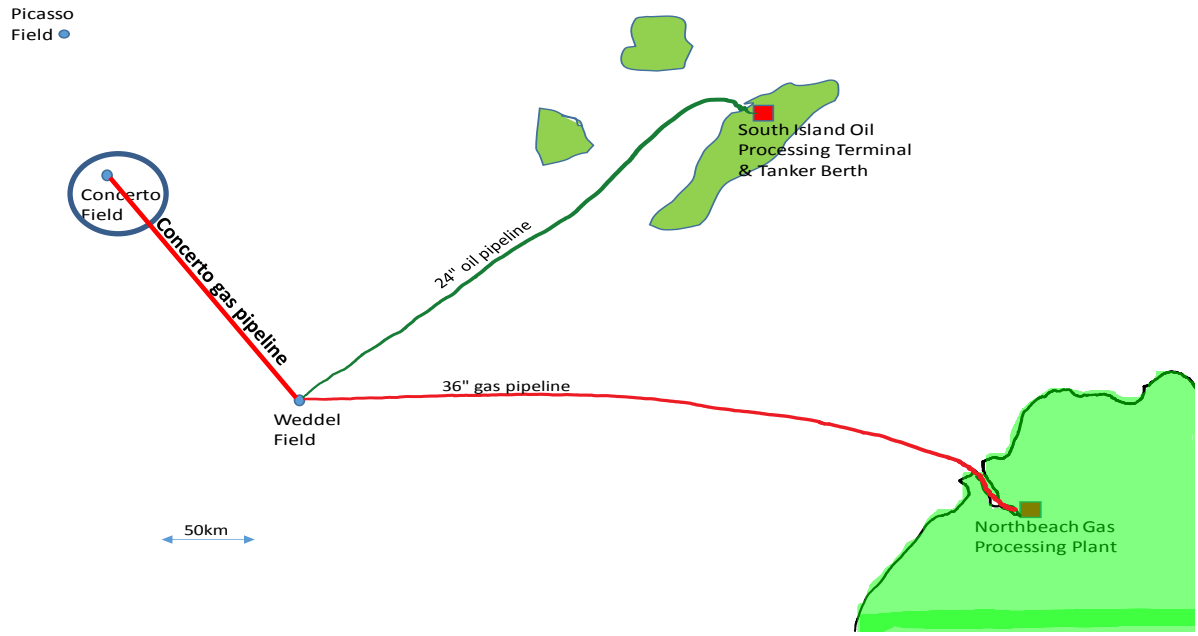
If we decide just to use FPSO vessel without a drilling unit, production will be interrupted when these future wells will need to be drilled and this could lead to a huge economic loss.
To optimise Concerto field production, Solar Oil needs a platform that can simultaneously drill wells during production with no production interruption. This remains the main reason on which I've recommended the use of FPDSO [5] for Concerto field development.
With this, Concerto field cannot share any facility with Picasso.

7.2 Weddel Field



- Located 50km south of concerto field, a spar platform with oil and gas pipelines, no tie-backs to either pipeline.

Since I've recommended FPDSO platform, Oil Tanker and Gas Pipeline for Concerto field, the sharing opportunity left with Weddel field will be to transport Concerto field gas to the export point through Weddel gas pipeline. To do this Solar Oil just need to connect or tie back Concerto gas pipeline to Weddel gas pipeline since Displacement meter will be installed on Concerto platform to measure the volume of gas leaving after processing.
This will be beneficial to Solar Oil economically. Since the distance from Concerto field to Weddel field is 50km, the cost of laying pipeline will drop from $2bn (if it is to be laid to the export point directly which is 350km excluding additional cost of managing pipeline crossing) to $286m based on estimated $3,640,000 per mile for pipe lay [2].



8 Conclusion

Having done all necessary evaluations within the scope of my assessment, a summary of my Recommendations to Solar Oil for the Optimum development and Production of Concerto field are as below:

Field: Concerto

Offtake System: Oil Tanker and Gas Pipeline tie back to Weddel field Gas Pipeline

Production Support: FPDSO

Comment: My recommendations have been influenced to a greater extent by Technical factors and to a lesser extent by Economics.

References

[1] Rafati, R. (2013/14): 'Energy Technologies'. *Oil and Gas*. Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_tab_group_id=_2_1&url=%2Fwebapps%2Fblackboard%2Fexecute%2Flauncher%3Ftype%3DCourse%26id%3D_16855_1%26url%3D

[2] Fee D, O'Dea J editors. Technology for developing marginal Offshore Oil fields. USA and London: Elsevier Applied Science; 2005, p. 285.

[3] Max, R. (2013/14): 'Facilities Engineering'. *Structures and Case Studies.* Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fexecute%2Fcontent%2Ffile%3Fcmd%3Dview%26content_id%3D_634106_1%26course_id%3D_16901_1%26framesetWrapped%3Dtrue

[4] David, A. (2011/12): 'Facilities Engineering' *Offshore Structures*. Available at: https://abdn.blackboard.com/bbcswebdav/pid-507524-dt-content-rid-1536531_1/courses/EG5562_13/EG5562_11_ImportedContent_20110829113759/Facilities%20Course%20Notes/TOPIC%2012%20-%20Structures.pdf

[5] Kazuo N, Paulo M, Carlos F, Daniel C, Marcos C, Vinicius M, editors. *A Study of Motion Minimization Devices of FPDSOs*. 20th International Conference on Offshore Mechanics and Artic Engineering; June 3-8; Brazil: ASME; 2001.

[6] NIKSAM LTD. FPDSO/ FPSO/ FSO. 2013; Available at: http://www.niksam.com.sg/services/fpdso-fpso-fso. Accessed 12 April, 2014.

[7] Mather A. editor. Offshore engineering: an introduction. 2nd Edition ed. London: Witherby & Co; 2000, p. 337-32.

[8] Offshore Technology. Bonga Deepwater project, Niger Delta, Nigeria. Available at: http://www.offshore-technology.com/projects/bonga/. Accessed 11th April, 2014.

[9] Jahn F, Cook M, Graham M editors. Hydrocarbon Exploration and Production. 2nd Edition ed. Netherlands: Elsevier; 1998, p. 433.

[10] Kjetil S. Norwegian Deepwater Program; Riser and Mooring. 2011; Available at: http://www.ndwp.org/readimage.aspx?asset=200. Accessed 11th April, 2014.

[11] Max, R. (2013/14) 'Facilities Engineering' *Offtake Systems*. Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fexecute%2Fcontent%2Ffile%3Fcmd%3Dview%26content_id%3D_629644_1%26course_id%3D_16901_1%26framesetWrapped%3Dtrue

[12] BP. Oil Prices. 2012; Available at: http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013/review-by-energy-type/oil/oil-prices.html. Accessed 12th April, 2014.

[13] Gomez J. (2013/14) 'Energy Technologies' *CCS Technology*. Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_tab_group_id=_2_1&url=%2Fwebapps%2Fblackboard%2Fexecute%2Flauncher%3Ftype%3DCourse%26id%3D_16855_1%26url%3D

[14] Max R. (2013/14) 'Facilities Engineering' *Produced Water processing*. Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fexecute%2Fcontent%2Ffile%3Fcmd%3Dview%26content_id%3D_629166_1%26course_id%3D_16901_1%26framesetWrapped%3Dtrue

[15] Max R. (2013/14) 'Facilities Engineering' *Oil and Gas Processing*. Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fexecute%2Fcontent%2Ffile%3Fcmd%3Dview%26content_id%3D_627403_1%26course_id%3D_16901_1%26framesetWrapped%3Dtrue

[16] Max R. (2013/14) 'Facilities Engineering' *Metering and Allocation*. Available at: https://abdn.blackboard.com/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fexecute%2Fcontent%2Ffile%3Fcmd%3Dview%26content_id%3D_639580_1%26course_id%3D_16901_1%26framesetWrapped%3Dtrue

[17] International Association of Oil and Gas Producers. OSPAR Moves a Step Closer to passing a Recommendation on Produced Water discharges. 2012; Available at: http://www.ogp.org.uk/news/2012/april/ospar-moves-a-step-closer-to-passing-a-recommendation-on-produced-water-discharges/. Accessed 11th April, 2014.

[18] OSPAR COMMISSION. Risk-Based Approach to the Management of Produced Water Discharges from Offshore Installations. 2012; Available at: http://www.ospar.org/html_documents/ospar/html/data/assessment_fact_sheets/ospar_factsheet_rba_2013.pdf. Accessed 11 April, 2014.