

# Field development concept scenarios for Pohokura

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## Abstract

The Pohokura gas-condensate field is a low relief anticline, approximately 16 km long by 5 km wide, extending offshore in a NW direction, from close to the Methanex Motunui site near Waitara in North Taranaki. The field was discovered by Pohokura-1 (130 m gas column) in the Eocene Mangahewa Formation in February 2000 by the joint venture comprising, at that time of Fletcher Challenge Energy, Preussag Energie, Shell Petroleum Mining and Todd Petroleum Mining and operated by Fletcher Challenge Energy. The field was successfully appraised by Pohokura-2 (115 m gas column) in May 2000, testing the central part of the structure 5 kms NNW of the discovery well. The two wells flowed on DST at 0.5 million sm<sup>3</sup>/d and 1.0 million sm<sup>3</sup>/d respectively.

A 3D seismic survey was conducted over the entire field late in the year 2000. Extensive interpretation of this data is currently underway. Subsurface static and dynamic modeling of the field has commenced but is currently immature.

There is an opportunity for gas sales from Pohokura to commence in 2005. To achieve this startup there are two critical activities and dates, which the Project Team has to meet. Firstly the lodging of applications for Resource Consents early in 2002. In order to achieve this a wide envelope of development concepts has to be identified to prepare assessments of environmental effects (AEEs). Secondly, the Front End Engineering Design of the Project must also commence in early 2002 to ensure that a Final Investment Decision can be made at the end of 2002, which will only leave a 2 year period for the Project Execution.

The challenge for the Development Team within Shell Todd Oil Services Ltd (STOS) is to determine the optimal development concept, whilst there is still significant subsurface uncertainty. This is being managed by close cooperation between the surface and subsurface disciplines. A large number of "building blocks" have been established, i.e. different types and sizes of gas plants, and the optimum concept is being determined using a scenario based approach linked to an economic model and decision tree.

The paper describes these options and gives some indications as to the likely development concept for the forthcoming Pohokura development.

## Introduction

Subsequent to the Shell acquisition of FCE the Pohokura permit is now owned by Shell Petroleum Mining (51.7% share) Preussag Energie (33.3% share) and Todd Petroleum Mining (15% share). Shell Petroleum Mining have also committed to the NZ Commerce Commission to divest a 3.67% interest. Although the Operatorship remains formally with an ex FCE Shell subsidiary, the Field Development is being undertaken by Shell Todd Oil Services Ltd.

Shell Todd Oil Services set up a Project Team in mid 2001 to continue with the field evaluation work commenced by Fletcher Challenge Energy after the field was discovered in February 2000. The Project Team is fully integrated with

geoscience, petroleum engineering and surface engineering specialists. The current focus is on developing a better understanding of the Pohokura reservoir, assessing reserves and determining the most optimum way of developing the field. A large number of conceptual studies have been undertaken both in-house and utilising the expertise of local engineering consultant Transfield Worley in New Plymouth.

The paper will give some background to the status of the studies, describe the concepts that have been evaluated and give some indications as to the likely development concept for the forthcoming Pohokura development.

## Pohokura and the New Zealand gas market.

The Pohokura gas field is currently estimated to hold reserves, at a level of around 1000 PJ. This makes it by far the largest undeveloped gas resource in New Zealand.

Several major NZ gas users have indicated interest in purchasing Pohokura gas for long term supply, starting in 2005. The ultimate plateau rate and build-up to plateau will be derived from commercial negotiations with these potential gas purchasers. Plant capacities in the range of 70-120 PJ/annum are being considered.

## Potential products from the Pohokura field

Well tests from both Pohokura-1 and 2 revealed condensate to gas ratios, at separator conditions of around 70 bbls/mmscf. These translate to 75 to 80 bbls of stabilised condensate per mmscf of sales gas when a full scale complex gas processing plant is simulated. Therefore condensate production from the Pohokura field will be an important product, with production in the early years of up to 30,000 barrels/day (5000 m<sup>3</sup>/d).

With the relatively rich composition of the wellstream LPG components, propane and butane are also present in significant quantities. If these are efficiently extracted LPG production may be in excess of 300,000 tonnes per annum, depending on the quantity of sales gas produced. Therefore LPG is potentially another significant product of the Pohokura field.

Another potential product is light naphtha. This would be separated from the condensate to produce an enhanced condensate, containing virtually no benzene or benzene precursors, and a light chemical naphtha feedstock. Approximately 20% of the condensate could be extracted as naphtha. The enhanced condensate is likely to be more attractive to potential oil refiners, as benzene levels in petrol would be minimised. The resultant benzene content of naphtha is less significant as this is likely to be cracked to light olefins in an ethylene plant.

A decision on whether to make naphtha as a product will be based on an economic evaluation and will depend on the value of a full run condensate, compared to separate enhanced condensate and naphtha products.

## Sub-surface development status

The Pohokura gas condensate field is currently being appraised to determine the structural extent, reservoir quality and potential recovery of hydrocarbons. Two wells have been drilled on the structure, the initial exploration well Pohokura-1 penetrated a 130 m gas column and the appraisal well Pohokura-2, encountered a 115 m gas column in the central part of the structure 5 kms NNW of the discovery well. The two wells flowed on drill stem test at 0.5 million sm<sup>3</sup>/d (17

mmscf/d) and 1.0 million Sm<sup>3</sup>/d (35 mmscf/d) respectively. A further well, Pohokura South, was drilled in March 2001 in the saddle area between the Pohokura and Mangahewa field structures, however, sand quality was poor in the reservoir section and no movable hydrocarbons were found in the Mangahewa formation.

A 3D seismic survey was conducted over the entire field, in late 2000 and early 2001, including both a marine survey and a transition zone survey across the shallow inshore area and shoreline. Preliminary processing of the marine survey was completed in mid 2001, which has allowed a first pass interpretation to be completed. Final processing and merging of the marine and transition zone data sets was completed in October 2001 and final interpretation has now commenced.

A further appraisal drilling campaign is planned for the coming year. The appraisal well objectives are to determine the numbers of offshore platforms and their locations, determine the balance between onshore and offshore development wells, improve confidence/reduce the uncertainty range in reserve estimates and reduce the uncertainty range. It is comprised of the following activities:

- Drill a sidetrack well from the Pohokura South Wellsite to ascertain the southern extent of the field, reduce GIIP uncertainty and further evaluate geological and petrophysical properties in this region of the field. This well may also be tested to determine the maximum and sustainable production rate for a typical deviated development well.
- Drill an additional well in the north of the field to ascertain the northern extent of the field, reduce GIIP uncertainty, act as a structural control point and ascertain whether the high permeability layers evident in Pohokura 2 are present in the northern extremities of the field.

These wells are planned to be drilled between April and August of 2002.

Preliminary subsurface static and dynamic modelling of the field has been undertaken over the last three months, based on the initial seismic interpretation. This has resulted in a range of potential subsurface scenarios being developed using Shell proprietary static and dynamic modelling software.

In order to mature the understanding of the Pohokura field the subsurface studies will focus on incorporation of all detailed petrophysical information (including SCAL results) into the dynamic model, refining of static and dynamic models as interpretation and inversion of the 3D seismic progresses. This will also include taking into account the results of the two appraisal wells. Optimisation of well numbers, type (horizontal, vertical, highly deviated, intelligent!) and recompletion potential, the impact of aquifer strength and faulting/ compartmentalisation on recoveries and the potential for gas recycling to increase and accelerate liquids production will also be reviewed.

An integrated sub surface development plan for the Pohokura field is currently scheduled to be completed towards the end of 2002.

## Pohokura development timeline

To meet the expected opening window of opportunity for gas in the market place the field is targeted to be onstream in 2005. Regardless of the development concept selected the project has a tight timeframe in order to meet this startup date. In order to reach a Final Investment Decision (FID) a number of major activities require completion in 2002. These can be summarised as follows:

- The Field Development Plan which defines the range of reserves, production profiles, number of wells and timing.
- A full Project Specification detailing the entire project scope for offshore facilities, onshore plant and all pipelines and storage facilities.
- A detailed cost estimate suitable for Project Sanction.
- A Project Execution Plan, which defines the Project's Contracting Strategy and details each step in the execution phase.
- All Resource consents for the Project must have been obtained.
- Arrangements put in place for purchasing land required for project facilities.
- Contracts put in place for the sale of a quantity of gas, sufficient to ensure the economic success of the project.

In order to achieve all these goals a development concept must be selected by the end of first quarter 2002. This will allow the front end engineering of this concept to commence to ensure that the Project Specification, Project Execution Plan and Cost Estimates can be developed with sufficient detail to allow the Final Investment Decision to be taken. All applications for Resource Consents are being lodged early in 2002 with the aim of ensuring that all Consents will be in place by year end. The applications are being based on an envelope of development options which have been identified and the assessments of the environmental effects (AEEs) has been determined for these concepts as an integral part of the consent process. As the consent process progresses over the next few months the envelope of options (e.g. one, two or three offshore platforms) will be narrowed down.

A decision on the development concept for Pohokura has therefore to be made before the completion of the sub-surface studies and Field Development Plan to ensure that a Project start up in 2005 can be achieved. The challenge for the Development Team within STOS is to determine the optimal development concept, whilst there is still significant subsurface uncertainty. This is being managed by close cooperation between the surface and subsurface disciplines.

## Development concepts

A large number of development concepts have been screened for Pohokura. Some of these have been eliminated, either on

technical or commercial grounds, whilst some are still being evaluated. A building block approach has been developed to evaluate offshore, onshore processing and storage options. The options that have been evaluated are described below:

## Offshore facilities

The Pohokura field is located close to shore, with its northern extremity approximately 15 km from the beach. Figure 1 identifies a possible three platform development

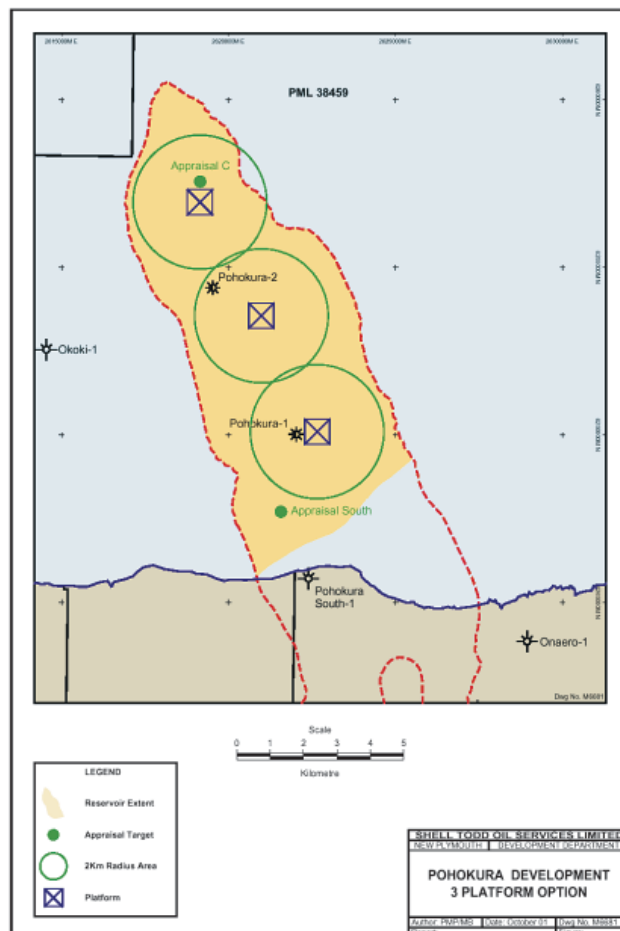


Figure 1: Extent of Pohokura Field

Water depths increase gradually to approximately 50 m in the north. Three different alternatives have been examined for providing infrastructure to allow development wells to be drilled into the field. These are:

- I. Provide small wellhead platforms from which a number of wells with dry trees can be drilled. These would be tied back to the shore at Motunui with a multiphase wellstream pipeline.
- II. Drill extended reach wells from drilling sites along the coast in the Motunui area.
- III. Drill subsea wells, either in clusters, or in isolated locations over the field. These would be gathered together in a manifold or daisy chained and tied back to the shore at Motunui with a multiphase wellstream pipeline.

The subsea option has been eliminated on technical and economic grounds. Subsea wells in this shallow water depth would provide a hazard for local fishing, capital costs are high and well intervention is costly.

The deployment of extended reach wells alone is not considered feasible from a technical perspective as the longest wells would have to be in the order of a 14 km step out. The current world record step out for an extended reach well is around 10 km. Also the cost of long extended reach wells are high due to the technical challenges and specialist nature of the drilling rig. However some extended reach wells from shore may be drilled, with a step out up to approximately 3.5 km. The number will depend on the extent and quality of the reservoir in the southern part of the field, which will be determined from the results of the forthcoming appraisal campaign.

The use of small wellhead platforms for the development of shallow water fields is a well proven concept. Providing the size of the platforms can be kept to a minimum, the costs are also relatively low, typically equal to the cost of drilling an offshore well. The concept, being considered, is for between one and three wellhead platforms, installed with a jack up rig, each with up to six wells.

In order to maintain simplicity on the platform, consideration is being given to eliminate the helideck. All access would be via vertical ladders using a purpose built support craft. This craft provides all life support when the platform is manned. Therefore many of the facilities normally associated with an offshore installation, i.e. helideck, lifeboat, temporary safe refuge, power generation, fire and gas system, etc can be eliminated. This concept has been developed and proven by Shell Expro in the North Sea and it is currently being determined if it can be adapted to the local Taranaki offshore environment, see Figure 2.

In this concept each of the platform's legs is also a conductor allowing a well to be drilled through each leg, which also

acts as a pile. The total weight of this type of facility, including sub structure and topsides is in the order of 400 tonnes. It therefore has the potential to be built locally within Taranaki.

The downside with this type of installation is that in certain weather conditions access to the platform to undertake essential maintenance activities may not be possible. Marine access is not considered acceptable, from a safety viewpoint, if the maximum significant wave height is above 1.5 m. This means that, particularly in the winter months, there may be periods of up to 2 weeks when the platforms cannot be accessed. To cater for this there must be redundancy, both with platforms and wells.

Another issue, which has to be resolved with this type of installation, is the requirement for well intervention. In order to undertake major well activities, i.e. a full workover, then it is necessary to mobilise a jack-up rig. However, for undertaking wireline, and potentially coiled tubing work, there are a number of alternatives which are currently being investigated. These include the use of a purpose built jack-up barge, which can act as a tender, or extending the facility such that a wireline unit can be accommodated on the deck, supported by a purpose built work boat.

The base concept is currently an offshore development with this type of unmanned wellhead platform and a multiphase pipeline to an onshore processing plant. A number of extended reach wells will also be drilled from onshore. The actual number of platforms and their exact location will not however be determined until the completion of the Field Development Plan.

## Onshore processing options

The raw Pohokura gas requires processing to meet a sales gas specification, assumed to be the New Zealand Specification for Reticulated Gas, NZS 5442, 1999. The minimum level of processing involves water and hydrocarbon dewpointing, and potentially some CO<sub>2</sub> removal to ensure



Figure 2: Shell Expro Trident Concept

that the Wobbe Index of the sales gas lies within the NZS 5442 limits of 46 to 52 MJ/m<sup>3</sup>. Hydrocarbon dewpointing to a temperature of -10°C results in propane and butane being produced as products, as the quantity to be removed from the gas cannot be absorbed in the condensate. In order to separate propane, butane and condensate a fractionation plant, consisting of three fractionation columns is also required.

The simplest type of plant to achieve the sales gas specification is a Low Temperature Separator (LTS) plant, similar to the gas plant located at Maui Production Station (MPS). In fact one of the options considered was to build a new multiphase pipeline from Motunui to MPS, and process the gas utilising spare capacity at MPS. This pipeline would have followed the same route as the Maui export pipeline from Bertrand Road in the North to Oaonui in the South.

However, because of the likely operational complexity and cost of the pipeline, this option was deemed less attractive than building a greenfield LTS plant, at Motunui. A plant exporting 60 PJ /a of sales gas would produce in the order of 50,000 tonnes per annum each of propane and butane products. It is assumed that a new pipeline to Port Taranaki is constructed to export these products.

Much larger quantities of propane and butane can be extracted from the Pohokura gas stream whilst remaining within the gas specification if a cryogenic turboexpander plant is installed. This may prove attractive if the LPG can be marketed at a netback price approaching that of oil. Based on a \$16 /bbl oil price this could result in propane and butane prices close to NZ\$400/tonne. Note that current netback prices for LPG exported from New Zealand are generally significantly lower than this because of the high shipping cost associated with small parcels.

Propane recovery above 97.5% and butane recovery of 100% can be achieved with a turbo expander plant. This results in over 130,000 tonnes of propane and 70,000 tonnes of butane per annum being produced with gas sales of 60 PJ/a, an increase of 100% in LPG production, compared with the simple LTS plant.

The preferred site for the new Pohokura Production Station is in the Motunui area

## LPG storage and loadout options

An important element of the Pohokura Development Project is the requirement for additional LPG storage and loadout facilities. At one extreme, minimal new facilities could be built and the existing pressurised LPG facilities of STOS and Liquigas could be used for exporting the product. At the other extreme, new refrigerated propane and butane storage facilities could be constructed at the port which would allow export of these products in 40,000 m<sup>3</sup> fully refrigerated LPG carriers.

In the case of minimum new facilities in the order of 1000 tonnes of new pressurised storage would be constructed at the plant site, to give some additional buffer storage and allow local road loadout of product. Export of propane and butane, when economic, would have to be in fully pressurised LPG ships, with an average parcel size of around 2000 tonnes. Export of large quantities of LPG would be expensive and a logistical challenge with in excess of 100 additional LPG cargoes per annum to be exported through Port Taranaki.

There are two alternative means of exporting propane and butane, both of which will increase the netback price of the product and reduce traffic at the port. The first is to use fully refrigerated ships, with a capacity around 20,000 tonnes. In order to achieve this refrigerated storage is required in the port vicinity to allow storage of 40,000 m<sup>3</sup> of butane and 30,000 m<sup>3</sup> of propane. A number of sites have been identified at the port, including a reclamation adjacent to the existing breakwater.



Figure 3: Potential New LPG Storage Site at Port Taranaki

A new refrigeration plant designed to cool butane to -5°C and propane to -40°C would also be constructed in this vicinity. Together with a new LPG berth located on the main breakwater this would minimise the length of large insulated loading lines.

The second alternative is to build new refrigerated storage at the Omata tank farm. In this case a 40,000 m<sup>3</sup> butane tank would be built together with two or three refrigerated spheres for propane with a capacity of around 25,000 m<sup>3</sup>. The propane product would be stored at a pressure of 3 barg and a temperature of -2°C, see Figure 4. Both propane and butane would then be loaded onto ships via an existing 18" white product loading line. Butane could still be loaded onto a fully refrigerated tanker, but propane would be loaded onto a semi refrigerated tanker, of capacity 15,000 to 20,000 m<sup>3</sup>. A liquid circulation line and a vapour return line would be required to run from the port to the tankfarm at Omata. The circulation line would be used to circulate products after loadout to ensure no cross contamination between propane, butane and naphtha.



Figure 4: Potential LPG storage site at Omata.

The first option, exporting LPG in small pressurised tankers, as is currently employed with Maui LPG, is compatible with the simple LTS processing plant, where only partial extraction of LPG is achieved. Whereas, the other two options, fully refrigerated and semi refrigerated are both capital intensive and would require maximum LPG volumes to be attractive. This makes them both compatible with the turbo-expander plant option, where LPG recovery is maximised.

## Selection of the optimum development concept

In order to select an optimum development concept, to allow engineering design to proceed and consents to be lodged a number of different production scenarios have been identified. These scenarios cover the full range of possible reserves, take into account plateau production alternatives of 60PJ/a, 90 PJ/a and 120 PJ/a and consider both LTS and turbo expander plants. The number of wells, split between

onshore and offshore and number of platforms are defined for each scenario. From this definition, capital and operating costs for each scenario can be established.

Once production profiles have been developed for each scenario and capital and operating costs evaluated an economic analysis can be undertaken to determine net present value, return on investment, value-investment ratio and payback period. A decision tree approach can then be adopted to determine the optimum development and the Projects expected monetary value (EMV). It is important that the selected development scenario is also evaluated against the minimum reserves to ensure that undue financial risk is not being carried by the JV partners.

This work is currently ongoing and is scheduled to be complete in March to allow selection of the optimum concept. Based on preliminary analysis it is currently considered likely that this concept will be a plant, located in the Motunui area incorporating a turbo expander for enhanced liquids recovery designed to maximise liquid recovery with a capacity of 11 million  $\text{sm}^3/\text{d}$  of gas and 8000  $\text{m}^3/\text{d}$  of liquids. New LPG storage and loadout facilities will be constructed at either Omata or Port Taranaki to allow export of LPG in either fully refrigerated or semi refrigerated tankers of 10,000 to 20,000  $\text{m}^3$  capacities.

## Acknowledgements

Acknowledgements are duly given to the Pohokura Joint Venture Partners, Shell Petroleum Mining, Preussag Energie and Todd Petroleum Mining together with Shell Todd Oil Services for their support and permission to publish this paper. The valuable contribution of the entire Pohokura Project Team, both within STOS and also independent consultants is also acknowledged.

## Author

Malcolm Beaumont is currently coordinating the concept studies within the Pohokura Project Team at Shell Todd Oil Services. Once the final concept has been selected he will be coordinating the development of the Pohokura asset.

Malcolm graduated from the University of Nottingham (UK) in 1978 with a BSc (Hons) in Chemical Engineering and has over 20 years experience working in the oil and gas industry in the UK, Europe with Shell, Australia with Woodside and New Zealand currently with STOS and previously with SBPT. Malcolm is currently working towards a Masters Degree in Petroleum Engineering at the University of New South Wales.