

# Quantifying undiscovered oil and gas in the Taranaki Basin

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## Abstract

A new approach is being undertaken to estimate undiscovered oil and gas in-place volumes in the Taranaki Basin using a probabilistic predictive model. The model is based on a set of hypotheses using a play analysis approach and artificial intelligence systems to characterise known reserves and geologic controls. This paper presents an introduction to this research, the approach being undertaken and its applicability to the industry.

## Introduction

Oil and gas was first discovered in the Taranaki Basin more than 100 years ago and the basin has seen at least 50 years of modern petroleum exploration and development. Geologically the basin promises to house many significant sized accumulations, and, in comparative terms, may be considered under-explored.

The discovery of the Kapuni Field in 1959 (total original recoverable reserves of 1443 BCF gas and 65 MMBBL oil/condensate) and the Maui Field in 1969 (total original

recoverable reserves of 3452 BCF gas and 184 MMBBL oil/condensate) proved the Taranaki Basin contained economically significant oil and gas reserves.

Maui makes up the bulk of discovered reserves with 63% oil/condensate and 76% gas of the total volumes discovered, as shown in Figure 1. This figure highlights that reserves discovered since 1970 equate to an average annual discovery of 47.7 BCF gas and 6.43 MMBBL oil and condensate. In energy terms this equates to 90.9 PJ<sup>1</sup> per year.

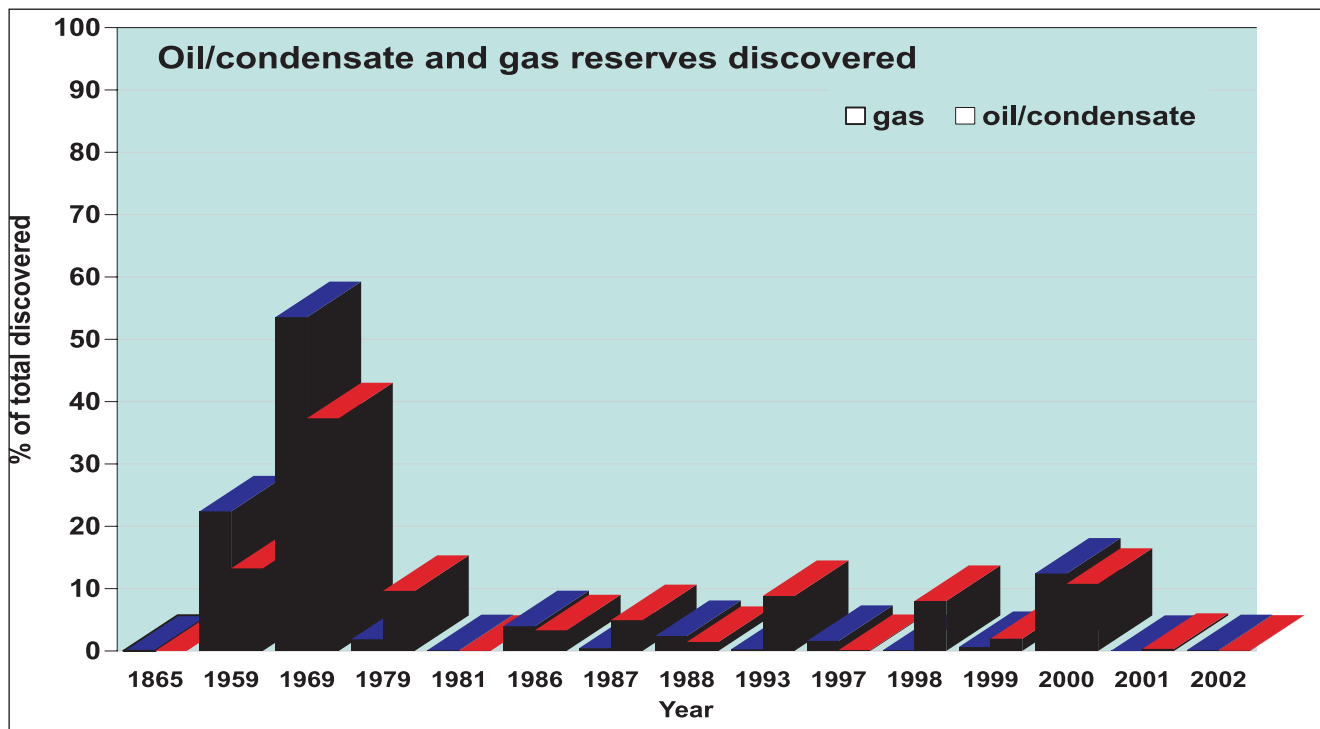


Figure 1. Percentages of oil/condensate and gas reserves discovered by year of discovery. Note that the x axis is a non-linear scale.

<sup>1</sup> Calculated using 5658 SCF = 1 BOE and 1MMBOE = 6.12PJ.

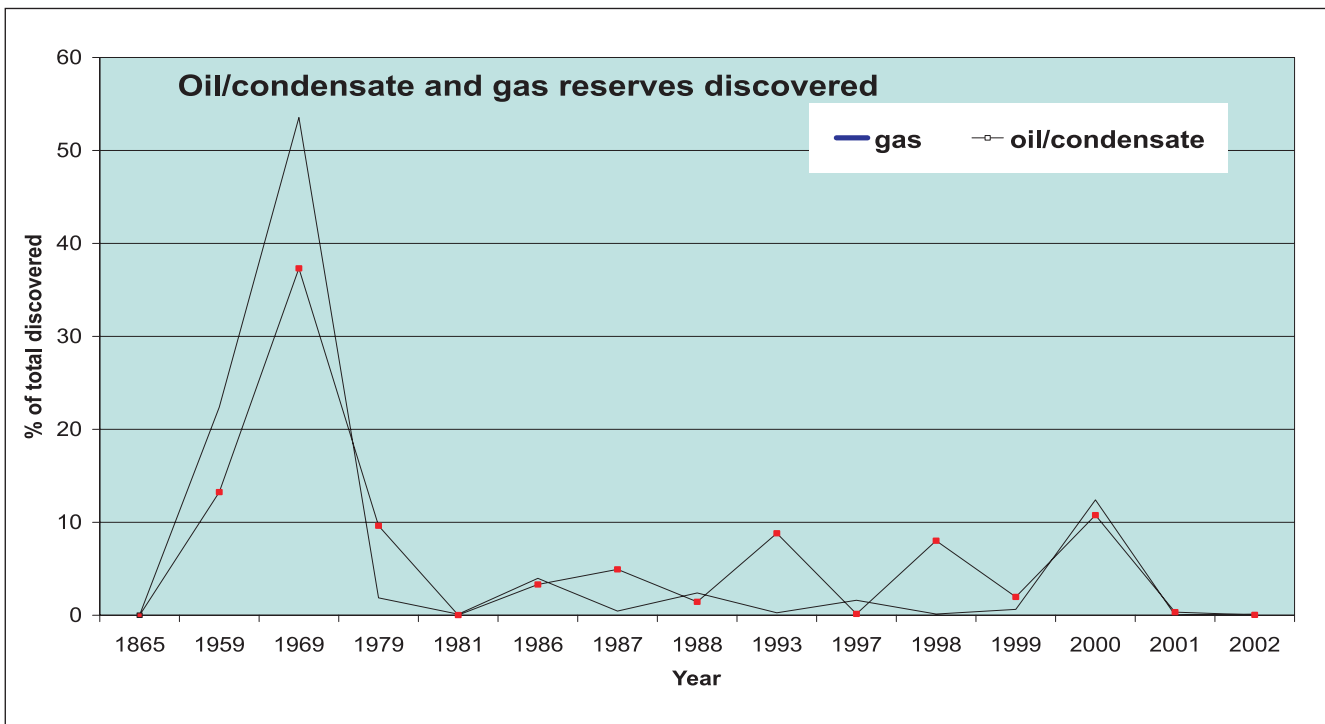


Figure 2. Oil/condensate and gas reserves discovered by year of discovery and as a percentage of the totals discovered. Note that the x axis is a non-linear scale.

As a first order trend there is a substantial decrease in reserves for all discoveries made since Maui, as shown in Figure 2. However, a second order trend shows that the reserves size of oil/condensate discoveries have progressively increased since 1981. Reserve size for gas discoveries have also increased from 1981 to 2000, however, with some smaller sized discoveries in-between.

Taranaki Basin's cumulative oil and gas reserves with each discovery are shown in Figure 3. The discovery record shows that between 1970 and 1999 the additional new discovery

reserves were modest with no single oil/condensate discovery being greater than 35 MMBBL and no gas discovery greater than 142 BCF gas.

### Taranaki Basin's discovered reserves

The Taranaki Basin is New Zealand's only economic petroleum producing basin. Petroleum accumulations have been discovered at every stratigraphic level from the Paleocene to Pliocene. The basin has approximately total

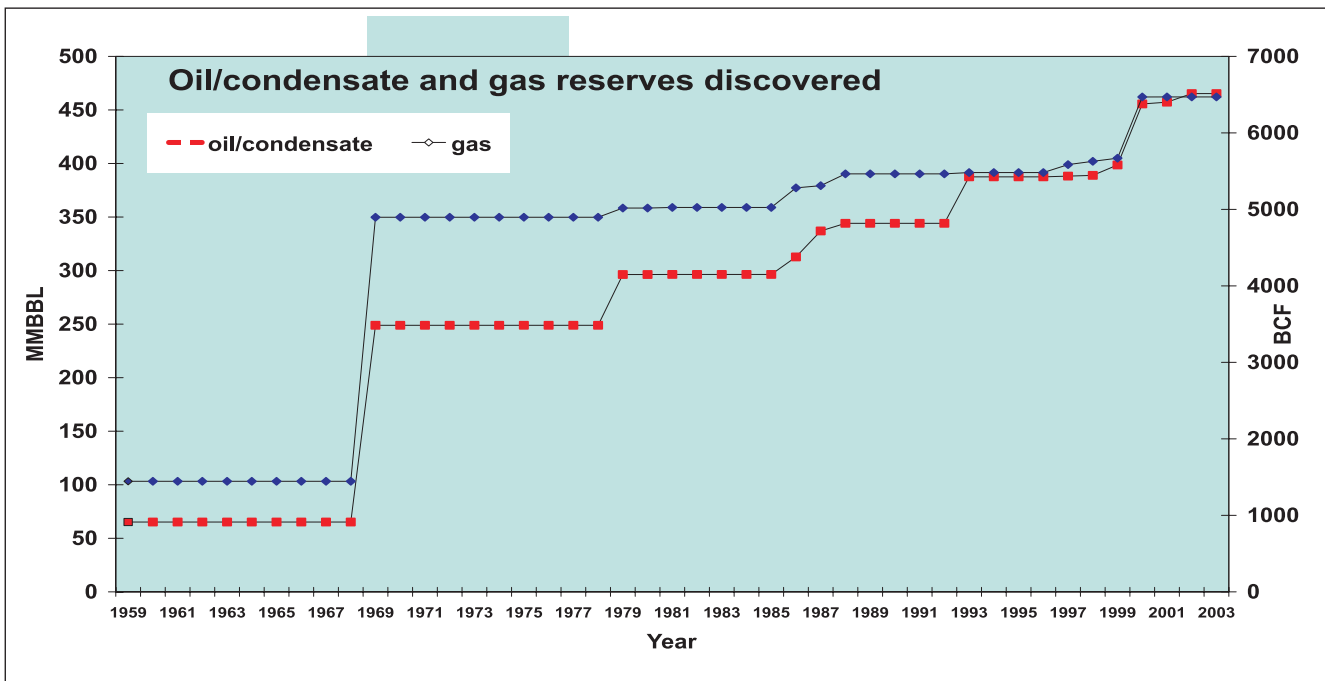


Figure 3. Cumulative oil/condensate and gas reserves in the Taranaki Basin.

recoverable original reserves of 465 MMBBL oil/condensate, 6470 BCF gas and 3.8 MT LPG, from a total of 20 pools including 14 producing or producible fields as shown in Figure 4.

Maui is the only producing offshore field and there are currently 10 onshore producing fields, Kapuni, McKee, Tariki/Ahuroa, Waihapa/Ngaere, Ngatoro, Kaimiro, Mangahewa, Rimu, Kahili and Surrey. Three offshore fields are under appraisal, Kupe, Maari and Pohokura. Two further discoveries have been made in established fields, Goldie and Kauri and some smaller discoveries are yet to be advanced, Windsor and Moturoa. Total remaining reserves stand at 54.5 mmbbls oil and condensate, 1321 bcf gas and 0.8 Mt LPG as at 30 June 2002 (MED 2002).

## Estimating undiscovered reserves

### Current estimation methodologies

Studies in stochastic methods of petroleum resource assessment in the last 25 years have resulted in a variety of estimation methodologies. In general five major types of estimation methodology are used globally including:

- direct expert assessment, also known as the Delphi approach (Baxter et al. (1978), Ivanhoe (1986) and Miller et al. (1975));
- areal and volumetric yield (Hendricks (1965, 1974), Jones (1975), Mallory (1975a) and Ulmishek and Harrison (1984));

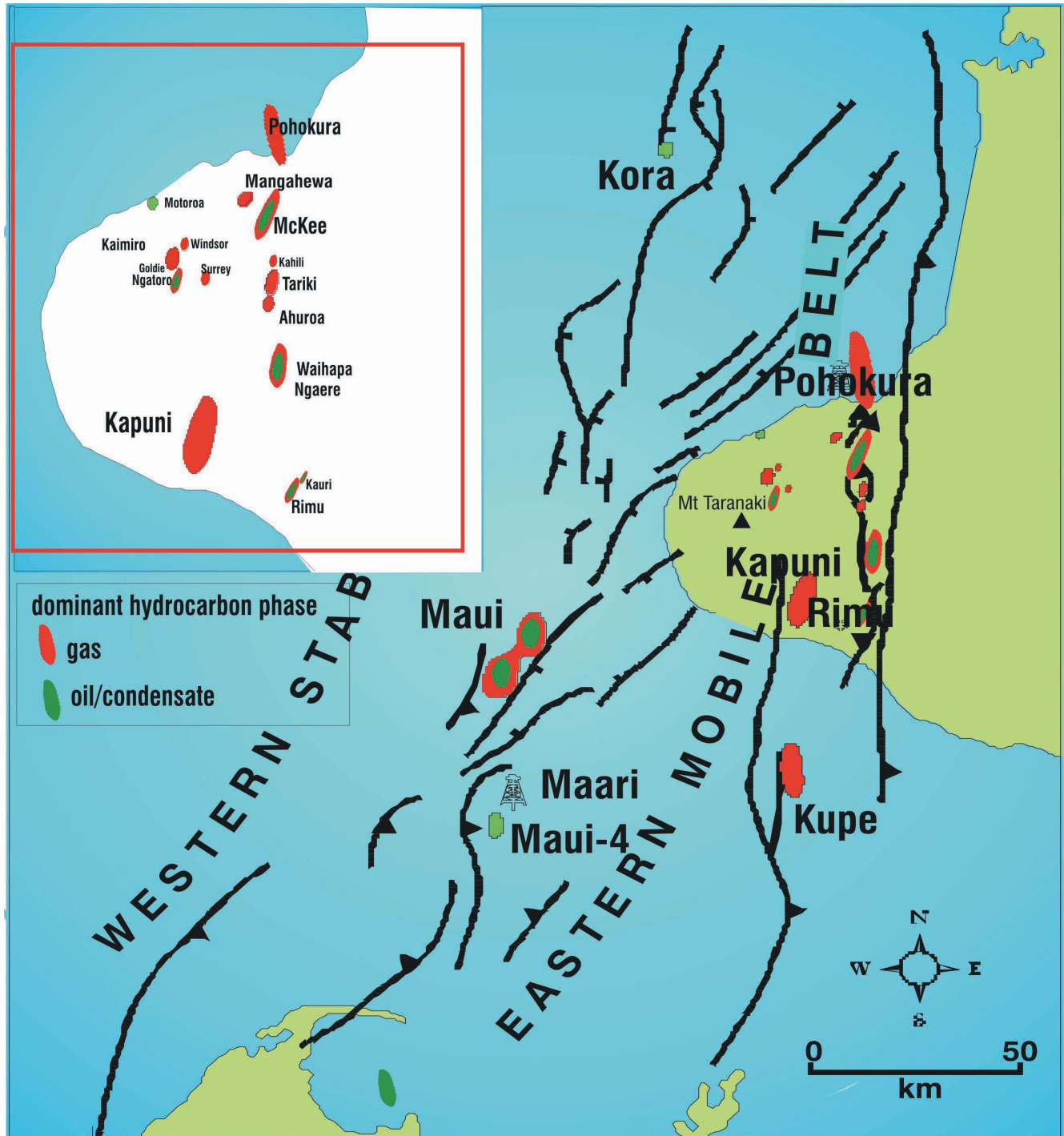


Figure 4. Taranaki Basin: main structural features and hydrocarbon accumulations.

- field size distribution (Harbaugh and Ducastring (1981), Kaufman (1963) and Schuenemeyer and Drew (1983));
- historical extrapolation (Arps-Roberts (1958), Barouch and Kaufman (1976a,b), Drew (1975a), Hubbert (1967), and Root and Schuenemeyer (1980)); and
- deposit modelling (Baker et al. (1984), and White (1981)).

Each of these approaches requires a different geological knowledge or degree of available data, and is applied for different reasons and possesses different limitations. Newer approaches to estimating undiscovered oil and gas volumes are employing more sophisticated computer models, incorporating a more realistic account of geologic risk and are reporting probabilistic ranges. Currently the two most popular methods involve curve fitting of field number and size and discovery record data in conjunction with gap analysis and extrapolation techniques (Kaufman et al 1975, Barouch and Kaufman 1977). An emerging area of reserve estimation sees the Delphi expert consensus approach being incorporated into quantitative analysis techniques involving basin modelling and Geographical Information Systems.

## Previous estimations made in the Taranaki Basin

Little work has been published on estimating undiscovered oil and gas volumes in the Taranaki Basin, as displayed in Table 1<sup>2</sup>. The estimates are mostly based on the assumption that the distribution of field sizes in a basin follows a lognormal distribution.

## A new approach to estimate undiscovered oil and gas

A play analysis approach and artificially intelligent soft computing techniques are being used to establish a set of hypotheses, concerning the Taranaki Basin's complex petroleum geology and its control on the distribution of oil and gas accumulations throughout the basin.

### Play analysis

A “play” describes the habitat in which an oil and gas accumulation exists. It is the set of discovered and undiscovered oil and gas accumulations that exhibit nearly identical geologic characteristics and are areally, positionally or structurally related. From an exploration point of view, the play concept accounts for all elements that contribute to and impact on risk. In this sense the geological characteristics are often used to quantify risk.

There are no guarantees that a play will yield oil and gas. This uncertainty will be accounted for by qualifying the two geological aspects which govern the presence or absence of hydrocarbons. The first aspect is “favorable geological conditions” which governs the establishment of a petroleum system. The second is “spatial and temporal controls” which govern the petroleum system components and influence the distribution and quantity of hydrocarbon accumulations. This first type can be thought of as the likeliness that the play contains accumulations of hydrocarbons and the second as whether or not a specific prospect is likely to contain hydrocarbons.

Taranaki Basin - Undiscovered Reserves Estimations							
Year	Author	Methodology Used	Discovery Size MMBOE	PJ equivalent	Distribution	In context	Success
1985	R Cook	Lognormal distribution (Perrodon 1983)	94	575	7 fields sized 7-18 MMBOE and 4 fields sized 2-4 MMBOE	Predates post 1985 discovered reserves	Did not predict Pohokura Field of 243 MMBOE
1993	M Beggs and R Cook	Statistical projection (Crovelli 1986)	79	484		In the Kapuni Group play. Predates Mangahewa, Ngatoro, Rimu, Kauri, Pohokura, Windsor and Goldie reserves	Did not predict Pohokura Field of 243 MMBOE
2002	Funnell et al	Lognormal distribution (Perrodon 1983)	997	6100	1 2000PJ field, 7 500 PJ fields and 6 onshore fields of 100PJ	Assumes Maui is the largest field in the basin.	
2002	Funnell et al	Modified Delphi	931	5700	8 onshore fields totalling 1.5tcf and 7 offshore fields totally 3.5tcf	Based on probability of commercial success	
2002	Funnell et al	Expected play discoveries	1144	7000	1000PJ in offshore Eocene play, 500PJ in Northern Graben play, 500-800PJ in thrust belt play and 100PJ in onshore Eocene play	In the Eocene, Northern Graben, deep Cretaceous, and eastern margin thrust belt plays	
2003	S O'Connor	Lognormal distribution (Perrodon 1983)	340	2081	1 field 125-250 of MMBOE and 82% of all fields <4MMBOE	Onshore only	

Table 1. Previous estimations of undiscovered oil/condensate and gas in the Taranaki Basin.

<sup>2</sup> All estimates, except for the 1985 one, are for gas only.

Uncertainties associated with “favourable geologic conditions” such as source rock or reservoir rock existence and uncertainties associated with the distribution controlling factor characteristics, such as reservoir porosity and trap size are determined using a risking structure, with the assumption that the characteristics are independent of each other. For each of the play characteristics, a probability that each characteristic is favourable is estimated from geologic data and combined to yield a “play probability”.

## Employing artificial intelligence (AI) systems

Even with good quality geological data the subterranean nature of oil and gas creates a high degree of interpretation and incomplete knowledge limiting the exact determination of in-place estimates. Artificially intelligent soft computing techniques such as evolutionary algorithms, fuzzy logic and neural and belief network systems are known for their ability to train data, incorporate uncertainty and partial data and perform problem-solving and decision-making tasks. Coupled with ever increasing computation power, these techniques are considered ideal for dealing with multidisciplinary data and uncertainty, both of which feature strongly in any attempt to estimate undiscovered oil and gas in-place.

Consequently two main AI approaches are being undertaken to develop the estimation model. The first relates to developing a knowledge-based system, commonly known as an expert system. This system will be used to collate what is known about Taranaki Basin accumulations and using pattern recognition techniques the accumulations and their controlling attributes will be characterised. The second approach employs connectionist networks, known as neural or belief networks and as stated above these networks will be used to train data to make the predictions.

## Applicability to the Industry

New Zealand’s petroleum exploration and development industry has entered a significant state of change and this transition period has resulted in a growing awareness of the supply and demand of indigenous oil and gas. The change is dominated by the near-depleted Maui Field which has provided 80% of New Zealand’s oil and gas for the last 30 years and is expected to be exhausted in 2007 (MED 2003a). Accompanied with this exiting major supplier, is a shortfall in replacement reserves and a growing demand for energy<sup>3</sup> which is predominantly met by oil and gas<sup>4</sup>.

With an established reliance on an indigenous oil and gas supply there is a practical need for a credible estimation of yet to be discovered oil and gas. Forecasts of expected reserves are an important part of economic supply functions, energy and resource planning, and development policy. The improved “best” estimates and a better understanding of the distribution of the oil and gas accumulations will be

instrumental in providing an up-to-date resource and prospectivity assessment of the Taranaki Basin.

## Conclusions

This presentation provides some insight into the new approach being undertaken to estimate undiscovered oil and gas volumes in the Taranaki Basin. An update of how much oil and gas is yet to be discovered in New Zealand’s only economically producing region will assist with future exploration and development, and energy management and planning. It is also anticipated that the methodology will be applicable to other New Zealand basins given they also exhibit similar regional Cretaceous to Cenozoic geology.

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<sup>3</sup> Consumer energy is expected to increase by an average annual rate of 0.6% from 546PJ in 2000 to 637PJ in 2005 (MED 2003b).

<sup>4</sup> Approximately 65% of New Zealand’s total energy supply is currently met by oil and gas.

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